Remain Chemical Engineers!

THIS IS NOT a baccalaureate sermon for those who are just entering our profession. It is addressed to some chemical engineers who have been out of college longer than they like to admit as well as to some industrial executives who are willing to look beyond today's expense accounts for tomorrow's profits. It is based on recent and rather intimate contacts with the petroleum, rubber, sugar, paint and paper industries. It is written from College Station, Texas, where the S.P.E.E. has just completed a three-day conference that revolved around the basic question: "Is the chemical engineering curriculum an adequate training for specialized industries?" The answer of the educators was unanimously favorable and they cited abundant evidence from industry that fundamental principles were much more important than technique and application. Yet in our contacts with the industries themselves we have lately noted some disquieting—perhaps dangerous—trends away from the basic concepts that have been responsible for the remarkable growth of chemical engineering.

In the petroleum industry, for example, there is a growing tendency to concentrate all technical activities in the single great trade association of that field. Many companies are discouraging outside contacts and will not authorize their employees to participate in the professional work of the engineering and scientific societies. In the rubber industry there is increased emphasis on group activity that tends to isolate its members—drawing them away from their fellow chemists and engineers in other lines of work. Among process industries none has gone quite so far as paint and varnish in concentrating and integrating its diversified interests. Pulp and paper manufacturers were among the first to support specialized courses in our schools and colleges and have de-

veloped an efficient, integrated organization of the entire industry. Other examples might be cited to show how, in varying degree, several process industries have started to radiate away from the basic nucleus of the chemical engineering profession. Is this a logical development or is it a trend that may prove dangerous both to the profession and to these specialized industries?

Certainly it would seem that in the future these industries are going to be more dependent than ever on chemical and engineering advances. Yet as they radiate away from the center of common interests, they become farther apart, more isolated from each other and must find it more difficult to draw on mutual knowledge and experience. Progress is slow if not impossible in an industry that feeds upon itself.

We know of one company that is taking definite steps to avoid such dire consequences. When young men are brought into its employ they are warned that they must remain chemical engineers and avoid becoming specialists in the technology or empiricism of some one branch of the business. The result has been that during the past few years this company has far outstripped its older and larger competitors. And it has made most of its advances through the ingenious application of chemical engineering processes and equipment that have come from *outside* of its specialized industry.

In industry as well as in our personal thinking and planning, it pays to get back to fundamentals. During the past thirty years the chemical engineering profession has risen to a commanding position in the national economy. It has advanced so rapidly and effectively because of its mutuality of interests—its ability to draw on the knowledge, experience and achievements of all of its members. That progress will continue at an accelerated pace if we remain chemical engineers.
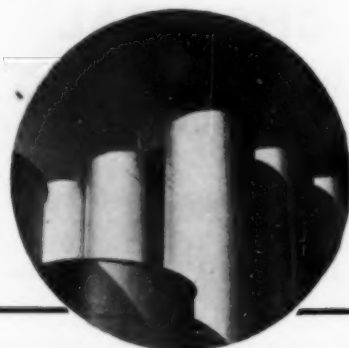
From an

EDUCATIONAL ORDERS

MOST OF THE $2,000,000 which the War Department will spend for supplies and equipment of a special nature, allocated to acquaint manufacturers with methods of production and quality of products required, will be spent for mechanical equipment. But in a few cases chemical industry should participate in order to familiarize itself fully with the ways in which the War Department needs must be met should a military emergency involving this country arise.

Chemical engineers and officials of firms which have been asked regarding capacity to produce or the meeting of specifications of a special sort should look into these possibilities. The funds available are limited. They will be distributed as widely and as wisely as possible. But if there are some training orders needed by chemical enterprise, requests for these should go at once to the Assistant Secretary of War's office, with as persuasive argument as can reasonably be made.

FOR THOSE SEEKING GUIDANCE

THIS MONTH or later this summer some young high school graduate is likely to come to you for advice about his future career. He may want to know what it takes to be an engineer. If so, there is much you can tell him but seldom have we seen it in such concentrated form as in a miniature monograph entitled "Chance and Choice in Engineering," which has been prepared by Dean R. L. Sackett of the E.C.P.D. Committee on Selection and Guidance.

Here is what he says that engineering education asks of a prospective student:

First: A definite liking for and ability in mathematics, particularly in solving problems.

Second: A scientific curiosity and a deep desire to know *why* and *how* force, electricity, heat and chemicals act and react as they do.

Third: An interest in drawing, doing things, making things, seeing through them and seeing them through, understanding mechanical, electrical and other devices, and an ability to see and think in three dimensions.

Fourth: Character, courage and a genuine ambition supported by dogged determination and many other qualities that are either necessary or helpful.

Those of us who are concerned with the future of our profession and want to see its standards raised, will do well to give sound counsel so that able boys with desirable interest will feel encouraged to apply for admission to an engineering college. By the same token, those who are attracted by the spectacular and the romantic, or by the lure of easy profits, should be made to understand the nature of the severe discipline ahead of them so that they make their decisions with their eyes open to the realities.

COAL VERSUS HYDRO POWER

CHEMICAL ENGINEERS are keenly aware of the controversy between hydro power and steam power which is being fought over by the coal producers and the proponents of further federal development of hydroelectric enterprises. If consulted, as apparently they have not been, these chemical engineers would be likely to answer the coal men who oppose multiplication of Tennessee Valley Authorities in some such fashion as this:

Process industries want power and want it as cheap as possible, regardless of the medium by which it is generated. For large electrochemical and electrothermal industry it has been necessary to have very cheap hydroelectric power, and to use this near the point of generation. But if coal can be used for power production in modern steam-electric plants to furnish cheaper energy, then the chemical engineer will be delighted. Under such circumstances he will presumably have a much greater freedom in choice of location for his processing plant, and not be tied to the tail race of a hydro unit.

Chemical engineers, therefore, ask the coal men —Why cannot steam-electric power in large quantities for high-load-factor business be made cheaper? Perhaps it can. All hope so. The most obvious obstacle is the high cost of hauling coal to the point of consumption (or raw materials to, and products from, the point of coal mining).

Is there not some way in which the coal man can make fundamental engineering advances in

Editorial Viewpoint

the delivery of energy to users in process industries? Is the transport of coal by gondola on rails most economical? Must we generate the power at the mine and move the electricity? What is process industry's part in the needed development of steam-electric generation and utilization?

Chemical engineers and coal men have a common interest in these problems. However, mere opposition to hydro power will not take the place of new technology or more favorable economic setting. The most persuasive argument will be lower cost of steam-electric energy. With it, subsidized hydro plants will likely become politically unfashionable.

DRAIN THOSE CONTAINERS!

ANOTHER RECORD for safety was made last year by the railroads of America. In the transportation and handling of all classes of chemicals, explosives, and other dangerous articles in Canada and in the United States there was no person killed, and only ten persons suffered from slight injuries.

This is a remarkable tribute to the adequacy of the regulations and the carefulness of the shippers, carriers, and the consignee customers. But nothing human is perfect. The record is marred a bit by the ten minor injury cases. A study of these shows clearly the major remaining causes of occasional injury. Chemical users should do just a little more to make the record more nearly perfect.

One of the persons injured was burned slightly in the fire following the derailment of a tank car of gasoline. In the other nine accidents, acids or corrosive liquids were involved. Three of these cases involved the handling of supposedly empty containers which had not been thoroughly drained by the user of the chemical before the containers were shipped on their return journey. In three other cases carelessness in unloading appears to have been the cause of acid burns. Thus six of the nine chemical injury accidents were at the customer destination. Just a little more care at that point is needed. It is particularly important that empty containers be thoroughly drained before reshipment. This is required by regulation and by common sense.

ELLERY LEWIS WILSON, 1882-1938
JOHN NORVIN COMPTON, 1894-1938

DURING THE PAST MONTH word has come of the death of two distinguished chemical engineers and intimate friends. Ellery Lewis Wilson was born into the chemical industry, the third generation of a family associated since 1854 with the Rumford Chemical Works, of which his grandfather had been one of the founders. He himself entered the business shortly after graduating from Brown University and made many valuable contributions to the company's development.

He had also been active in the affairs of the American Institute of Chemical Engineers, serving on many committees; as representative on the National Research Council; and for many years as director. Much of his time and energies had been devoted to fostering junior professional guidance through the formation of groups of young engineers. To the great sorrow of his host of friends he was taken ill on the opening day of the recent meeting in West Virginia and while he appeared to have recovered the end came a few days later.

Twenty years ago John Norvin Compton was a leader in a very small group at Mellon Institute that witnessed the birth of the synthetic aliphatic chemical industry. In the years that followed it was his responsibility to help in translating the brilliant discoveries of the laboratory, first to the semiworks plants at Clendenin and then to the huge industrial operations that characterize the South Charleston works of the Carbide and Carbon Chemicals Corp. The heart ailment that prevented his personal participation in the arrangements Norvin Compton made for the meeting of the Institute did not lessen his interest and enthusiasm. From what proved to be his death bed he cheerfully directed the work of his colleagues while Mrs. Compton ably helped with the ladies program. His last word to us was a friendly challenge to do a better job for the industry and the profession. It is a challenge in which all may share.

The high standards these engineers set in the performance of their chosen work, in their dealings with their fellow men and in their service to the communities in which they lived—all are part of a tradition that will long be cherished by the many who were privileged to be their friends.

Travelling With a Southern Editor

Having made a trip through the South at the height of the depression, this editor was amazed to find a spirit of optimism prevailing. There was no apparent let-up in the great industrial expansion program—new plants were being planned everywhere.

JAMES A. LEE
Managing Editor
Chemical & Metallurgical Engineering

IF YOU ARE one of those persons who are living in the pessimistic atmosphere that has prevailed in the East and are convinced, as so many are, that economic conditions in the United States have "gone to the dogs," I recommend leaving your troubles behind and taking the next plane South. In case you are only moderately pessimistic, you might stop off in the Mid-South, but if you are very far gone and need a strong shot of optimism to restore your confidence in this country of ours, go all the way down to the Southwest.

You will probably be as surprised, as I was, to find business going on almost as usual and a spirit of optimism prevailing everywhere. Much of this prosperity can be credited to the invasion from the East, Mid-West and even the Far West, not of an army in blue uniforms this time, but of capital constructing great industrial enterprises.

By this time everyone must be well aware of the great migration of the pulp and paper industry to the South, but probably few persons realize that under cover of that development, which has attracted nation-wide attention, a less spectacular but nevertheless tremendously important influx of chemical and other process industries has been taking place.

In order to get first-hand knowledge of the extent and probable duration of the movement, I recently spent a month in the South, travelling some 6,000 miles, visiting one industrial district after another in the area extending from the Mason and Dixon Line on the north to the Gulf of Mexico on the south; from the Rio Grande on the west to the Atlantic on the east.

I have visited the South many times, but I have never known it to be so prosperous and optimistic as it is today. Of course, some of this is due to the generous handout from Washington, but that does not account for all of the good feeling. New industrial plants are everywhere and the woods are full of representatives of the Northern process industries who are seeking sites for new plants. Eleven Eastern and Mid-Western pulp and paper companies were represented and probably every important chemical company in this country now has under construction or is seriously considering a new plant in the South. The proposed new plants cover a wide range of products and are well distributed over the whole South, although my attention was particularly attracted by the industrial centers that are rapidly developing along the Gulf and

Atlantic Coast lines from Texas to North Carolina.

My first stop was at Dallas which was "a sight for sore eyes." Out in the residential areas hundreds of new houses were under construction and down in the business section many warehouses were being built. Dallas is to the Southwest what Atlanta is to the Southeast, an important center of distribution. Almost every large concern selling in Texas, Arizona, Oklahoma and the other states of the Southwest has stocks in Dallas.

CAPITAL INVESTED IN NEW PLANTS

Corpus Christi $17,500,000
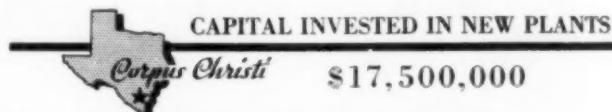
NEXT on my itinerary was Corpus Christi, the city that has had the unprecedented growth from a population of 10,000 in 1920 to 60,000 today. The opening of the port in 1926 added greatly to the many attractions of this area. They include extremely low-cost natural gas, deep-water transportation, adequate railroad service, lime obtained from oyster shells, glass sand, salt, barytes and other mineral resources. In recent years many industries utilizing the agricultural products and mineral resources of the neighborhood have been developed. There are 23 petroleum refineries, 25 cotton oil mills, three soap factories, one carbon black plant, and so forth.

However, the object of my visit was the plant of the Southern Alkali Corp. To the ammonia-soda department which was built in 1934 has recently been added a large installation of electrolytic chlorine cells to supply the rapidly developing market from the bleached kraft pulp industry, water purification, organic solvents and other chemicals. This is a splendid plant prepared to supply the alkali and chlorine requirements of the Southwest.

CAPITAL INVESTED IN NEW PLANTS
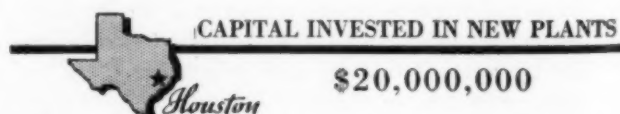
Houston $20,000,000

THE first stop on the return trip was made at Houston, the oil capital of the world. More than 500 oil companies maintain their headquarters in this city and it has been estimated that in the city and its outlying districts approximately 180,000 persons are directly dependent upon the industry for their livelihood. Although the American people haven't been buying new automobiles they have been burning more gasoline than they did last year. However, petrol-

eum refining is not the only process industry to be found in this port. Nearby are several important sulphur operations; while a few miles below the city on the ship channel are the new bleached kraft pulp mill of the Champion Paper & Fibre Co., and the new plant of the Gulf Portland Cement Co. Farther south at Texas City is the site of the synthetic organic chemicals plants of the Carbide & Carbon Chemicals Corp. on which construction is expected to start as soon as plans can be completed. Two other companies that are planning to produce synthetic organic chemicals from petroleum refinery gases are known to be looking for locations in the Southwest. If, as generally believed, this development has a bright future, Texas stands to gain tremendously from the movement.

CAPITAL INVESTED IN NEW PLANTS
Baton Rouge $27,000,000

BATON ROUGE is rapidly developing into an important chemical manufacturing center. Not so many years ago activity was limited to the refinery (the largest in the world) of the Standard Oil Co. of Louisiana and to the plant of the Consolidated Chemical Co., but in the past few years not only has the Standard Oil invested many millions of dollars in the manufacture of chemicals but other companies have joined the happy family. This group of concerns is of particular interest for its products are closely connected. The refinery was the first to arrive; it was followed by the Consolidated which supplied the refinery with sulphuric acid for the treatment of its gasoline. Next came the ethyl fluid plant of E. I. du Pont de Nemours & Co. The first unit has been quickly followed by one or two additional ones at a total cost of approximately $14,500,000. The Solvay Process Co. has recently completed a $1,000,000 electrolytic cell plant and a $7,000,000 ammonia-soda plant across the road from the refinery and the du Pont property. Caustic soda is now used in large volume for the refining of gasoline, and chlorinated solvents are being used in increasing quantities for the same purpose. And now comes word that the R. & H. Division of du Pont will put up a plant for the production of metallic sodium which is consumed in the manufacture of ethyl fluid. Who will be the next to join this group?

NEW ORLEANS was important industrially before some of these other southern cities were out of their swaddling clothes. For many years it has been a large producer of alcohol, cottonseed oil, refined sugar, heavy chemicals and other products and more recently to these have been added others. But because of its size the new enterprises are not making as great an impression as they are elsewhere. Over $26,000,000 has been invested in new plants.

CAPITAL INVESTED IN NEW PLANTS
Mobile $14,500,000

MOBILE will bear watching. It is developing into one of the outstanding centers of process industries and is likely to become much more important in the immediate future. The International Paper Co., through its subsidiary the Southern Kraft Corp., has two large mills located in the neighborhood; the Mobile Paper Co. is located there;

and the National Gypsum Co. had just completed an insulating board mill at the time of my visit. Hollingsworth and Whitney has joined the southern procession. Several hundred acres of land have been acquired on which construction of a $5,000,000 kraft pulp mill is expected to commence shortly. And rumors have at least one more pulp mill located there. But pulp and paper is not the only process industry in Mobile. One of the most impressive plants I had the pleasure of seeing on the entire trip was that of the Aluminum Ore Co.

Here, as everywhere else in the South, I encountered rumors about other process industries and met representative of companies seeking plant sites. While many of these may never materialize, at least one has done so in the interim since my visit. The American Cyanamid & Chemical Corp. has announced that a site at Mobile has been purchased for a chemical plant. Construction of the first unit will start immediately. The chief product will be sulphate of alumina which is used for water purification and the manufacture of kraft pulp.

CAPITAL INVESTED IN NEW PLANTS
Jacksonville $14,500,000

WE have become accustomed to thinking of Florida as a pleasure resort, but along the northern boundary are a number of large industrial enterprises, and the Jacksonville area is developing into an important manufacturing center. The kraft board mills of the National Container Corp., the Container Corp. of America, and the bleached sulphite mill of the Fernandina Pulp & Paper Co. are among the newcomers. This last mill is of particular interest as it will be the only mill in the South making rayon pulp from pine by the sulphite process. Construction is expected to be completed in the early fall. It has also been announced that a staple fiber plant will be erected nearby.

CAPITAL INVESTED IN NEW PLANTS
Savannah $12,000,000

I WAS fortunate in being in Savannah, Ga., at the time of the organization meeting of pulp and paper engineers. One of the speakers at the meeting made the statement that the development of the pulp and paper industry in the South would require annually 800,000 tons of salt cake, 300,000 tons of chlorine, and large quantities of clay, size, soda ash, alum, and other chemicals. In this connection comes the announcement that the American Cyanamid & Chemical Corp. has procured a tract of land at Savannah on which to build a plant for the manufacture of sulphate of alumina and miscellaneous heavy chemicals. While it is becoming best known for its pulp and paper manufacture, Savannah has long been important as the center of the naval stores industry in this country. It is also the home of many fertilizer and cottonseed oil mills, the Savannah Sugar Refinery and other process industries. Another new plant for the city will be the $1,000,000 wallboard mill of the National Gypsum Co. on which construction will soon start.

But not all the new industrial plants are locating in the several cities that have been selected for special mention, for it would seem that plants are under construction wherever one goes in the South. However, lack of available space, not of important centers, brings this to a close.

The Story of the Hooker Cell

How this modern diaphram type of electrolytic cell was developed at Niagara Falls and is now widely used throughout the United States for the production of caustic soda and chlorine. Essential features of the design and typical operating results from these cells are included among other things in this comprehensive article.

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CHLORINE was first produced commercially by reaction of sulphuric acid upon common salt in the presence of manganese dioxide. In 1871 Deacon improved upon this process by substituting sulphur trioxide and air for the sulphuric acid and manganese dioxide respectively. Chlorine was also produced by oxidizing byproduct hydrochloric acid. These reactions were employed, with variations, until the introduction of the electrolytic process.

The aqueous electrolytic alkali-chlorine process, as distinguished from electrolysis of fused salts, depends upon the decomposition of an alkali chloride in aqueous solution, liberating chlorine at the anode and alkali metal at the cathode. The alkali metal immediately reacts with the water present to form hydroxide and liberate hydrogen. If permitted, the chlorine will then recombine with the hydroxide to form hypochlorite or chlorate. If, as herein assumed, these are not the products wanted, this recombination must be prevented.

Use of the Bell Jar

The simplest way to do this is to house the anode in a bell jar. The chlorine then rises in the bell jar and the caustic alkali forms outside it. Diffusion of the caustic into the bell jar is prevented by the flow of fresh electrolyte into that compartment. The distance between anode and cathode in this type of cell is necessarily considerable. This caused such cells to operate at what would be considered a high voltage today.

As an alternative to the bell jar, it was proposed to separate the anode and cathode compartments by a permeable partition. All sorts of devices were proposed for this purpose. In one case, an attempt was made to use a bed of granular salt. Sand, powdered steatite and loose asbestos fiber were also suggested. The simplest form of diaphragm was a layer of granular material laid over a horizontal cathode of perforated steel. The percolation prevented the hydrogen from rising through the diaphragm. Other diaphragm cells were constructed with vertical electrodes and diaphragm between permeable retaining walls, which in some cases served also to hold in position the anode of granular carbon. A cell of this type was patented by Roberts in 1890. When asbestos became available in sheets, it began to be used in that form, as it is today. It was placed in contact with the perforated steel cathode. Percolation was set up by establishing a head on the anode side. Le Sueur patented a cell of this type in 1894.

Almost the only known metal which will resist nascent chlorine is platinum, the cost of which precludes its use in alkali-chlorine cells on a commercial scale. This leaves carbon as the only commercially available anode material. Some of the earliest anodes were of coal or coke in granular form or molded into rods by means of a binder, such as ozocerite. Coke was also used as it came from the oven, in irregular masses. Obviously these could not be placed close to the diaphragm. When graphitized carbon became available, it furnished an almost ideal material from which to make anodes for chlorine cells. It could be worked into any desired shape, and in the form of rods or plates is in universal use today.

In 1897 Kellner patented a cell in which mercury served as the cathode. In this cell the sodium forms an amalgam with the mercury; hence, no diaphragm is required. This cell produces caustic soda of very high purity and is in extensive use today. Nevertheless, on account of its relatively high initial and operating cost, it has not displaced the diaphragm cell, which produces caustic soda at a cost permitting of subsequent purification.

For a discussion of alkali-chlorine cell problems from the practical and theoretical point of view, refer to the article by A. H. Hooker, in the *Transactions of the American Institute of Chemical Engineers*, June 28, 1920.

Type "F" Cell

The Development and Funding Co., predecessor of the Hooker Electrochemical Co., was organized in 1903 to exploit the Clinton P. Townsend electrolytic cell patents (No. 779,383; 779,384 and 972,947). The Townsend cell, now called the Hooker type "F" cell, was of the type in which the cathodes form the side walls. It was operated at constant current and output by raising the head upon the diaphragm from time

to time, to overcome increasing resistance to percolation. The electrolyte was kept at saturation by rapidly circulating it through a saturating vault external to the cells. A special feature of this cell was that the cathode compartments were filled with a light hydrocarbon oil, in order to insulate the caustic soda from the cathode as quickly as possible after its formation. The Hooker type "F" cell had a current efficiency of 95 per cent or over, which is probably unsurpassed today.

Type "E" Cell

In 1913, Clarence W. Marsh then chief engineer of the Hooker Electrochemical Co., patented a modified type "F" cell (U. S. Patents No. 1,075,362; 1,075,363; 1,075,364 and 1,075,660). In this cell, now known as the Hooker type "E" cell, the cathode was corrugated into thin, elongated parallel compartments or "fingers" which alternated with plates or "blades" of graphite. The latter were, therefore, active on both sides. The upper and lower edges of the cathode fingers were protected by concrete. The diaphragm was of asbestos paper, folded into the corrugations, the edges of the paper being protected by putty, which overlapped the concrete. The cell occupied substantially the same floor space as the earlier type "F" cell.
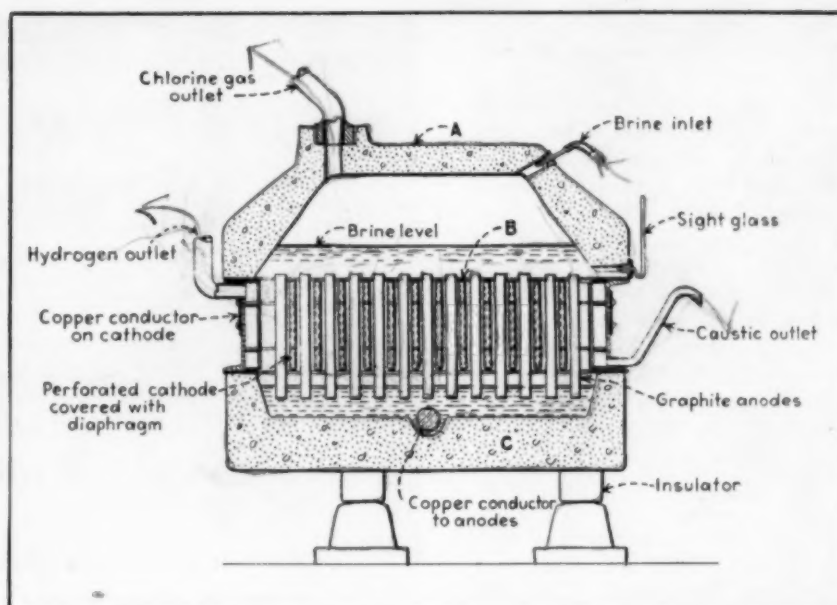

Essential characteristics of the Hooker type "S" electrolytic cell for making caustic soda and chlorine are shown in this diagram. The three parts are designated as *A*, concrete top; *B*, cathode assembly; and *C*, concrete bottom

It had considerably more electrode surface and when both cells were operated at 4,000 amp., it effected a saving of about ½ volt; with, however, a loss of about 3 per cent in current efficiency.

The oil in the cathode compartments of the Hooker type "F" and type "E" cells, however, was a considerable complication. Also, it tended to raise the cell voltage. In 1920, the oil was displaced by allowing the cathode compartment of the cell to fill up again with the electrolyzed brine. The specific gravity of this liquid being nearly the same as that of saturated brine, its presence tended hydrostatically to balance the electrolyte on the other side of the diaphragm. When the latter was built up to a higher level, a constant head was established upon every part of the diaphragm and uniform percolation resulted. It was found that the cells operated well in this way. The current efficiency was good and the voltage lower than before. This result was contrary to the generally accepted belief of that time that cells could not be efficiently operated with the cathode completely submerged. At about the same time, the system of circulating the electrolyte rapidly through the cells was discontinued. Instead, the cells were supplied with brine carrying excess salt in suspension. This was fed through a calibrated orifice under constant head (U. S. Patents 1,388,466; 1,388,474 and 1,423,584). Previously it had been the almost universal practice to maintain the electrolyte at constant level by supplying it to the cell through a float valve. As the diaphragm aged percolation diminished. The voltage impressed upon the circuit of cells was maintained constant, therefore the current diminished due to increasing resistance of the dia-

A new feature since 1929 is the deposited diaphragm. The cathode is immersed in a solution containing suspended asbestos which becomes attached to the cathode when the carrier liquid is drawn off through a screen by vacuum
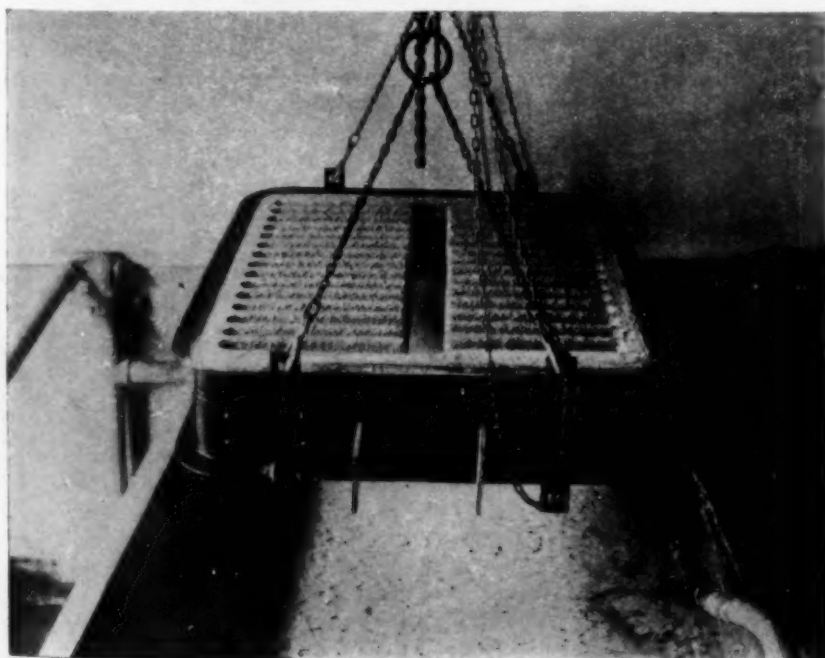
phragm. Hence, the output of the circuit decreased from day to day. This necessitated shutting down a whole circuit at a time for diaphragm renewal. By the system of supplying electrolyte through calibrated orifices, on the other hand, a constant quantity was supplied per unit of time, regardless of the age or condition of the diaphragm. The electrolyte was allowed to build up to a level just sufficient to overcome the resistance to its percolation through the diaphragm. As the diaphragm aged the level rose. When it reached the upper limit, the diaphragm was renewed. Renewals soon came at such intervals that in a large plant one or two could be made each day. The circuit of cells was operated at constant current. After about one year of operation the voltage of the circuit likewise became practically constant. The Hooker system of operation with constant feed therefore resulted in both constant voltage and constant output, whereas with the system of operation at constant level, when the voltage was kept constant the output varied, and vice versa.

The Deposited Diaphragm

In 1928, the unsatisfactory current efficiency of the type "E" cell, as compared with the older type "F" cell, was carefully investigated by Kenneth E. Stuart, then research engineer of the Hooker Electrochemical Co. He came to the conclusion that it was due to the lower temperature at which the type "E" cell operated and to breaking off of the putty from the edges of the diaphragm, which sometimes left bare cathode exposed. To remedy the latter fault, he undertook to eliminate the concrete and diaphragm edges within the cell and the necessity for protecting the latter with putty by forming the cathode fingers of wire screen folded in at the edges and corners and completely covered with asbestos. The resulting cathode fingers having, as they did, spherical and torus shaped surfaces at their corners and roots, could not be covered with a flat sheet of paper. Consequently, it was necessary to develop a process by which the asbestos diaphragm could be formed *in situ* to conform with the surfaces. This was accomplished as follows: The asbestos was suspended in a liquid of suitable specific gravity and viscosity, having at the same time the property of swelling and separating the fibers. The cathode was then
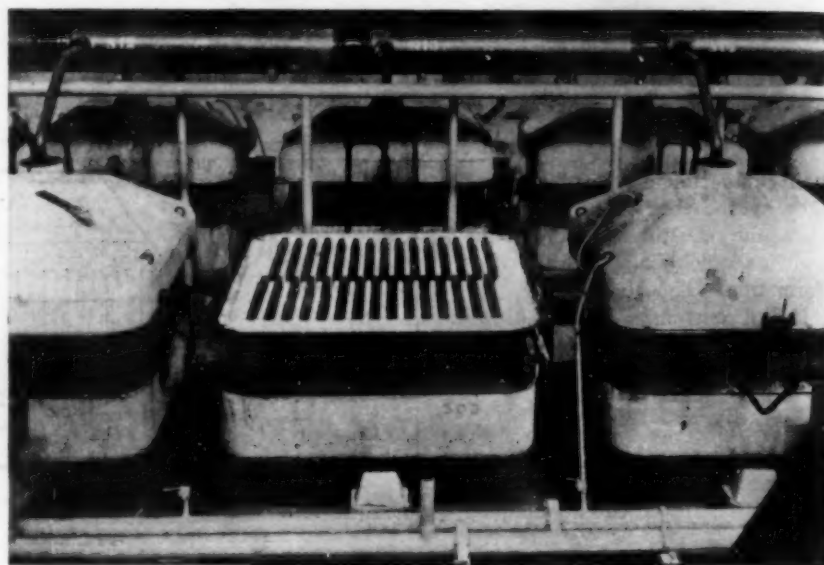
Cathode in position upon an anode assembly with the cover not yet in place. The extreme compactness of this type cell—70 sq. ft. floor space requirement per cell, including aisles—is apparent in this view

immersed in the suspension of the fiber and the liquid of the suspension drawn through the screen. When a certain vacuum had been built up, the cathode was lifted out of the depositing tank and drained and air drawn through the diaphragm, to compact and dry it. The whole operation required substantially less than an hour. (U. S. Patents No. 1,855,497; 1,862,244 and 1,865,152.) The result was a strong, firmly anchored diaphragm of uniform percolation density. The thickness of this diaphragm depended upon the quality and density of fiber used and the degree of vacuum applied at the finish.

Desirable Cell Characteristics

All the type "E" cells were modified to adapt them to the deposited diaphragm and an immediate improvement in both voltage and current efficiency was noted. It was soon realized that the deposited diaphragm feature rendered possible the construction of a cell of radically new type. A study of the problem brought out the following characteristics as desirable in an alkali-chlorine cell:

1. The electrode surface should be proportional to the cube of the linear dimension, instead of to the square, as in most of the cells in current use. This would make it possible to build units of any desirable size.

2. The electrode surface per square foot of floor space should be as great as practicable. This would economize not only building cost, but also labor for supervision.

3. The operating temperature should be high (i.e., approximately 90 deg. C). At this temperature the solubility of chlorine in brine, and, consequently, the loss in current efficiency due to chlorine passing through the diaphragm in solution, is much reduced.

4. The current density for cells of this type should be between 60 and 70 amp. per sq.ft. of anode surface. A lower current density would result in too low an operating temperature for best current efficiency. A higher current density would result in too high a voltage for best power efficiency.

5. The height of the anodes should be moderate, because of the blanketing effect upon the upper part of the electrode due to bubbles of chlorine liberated upon the lower part.

6. The radiation surface should be as small as consistent with other considerations. In this way the heat developed within the cell, instead of being dissipated in the atmosphere, would be utilized to evaporate water, thus helping to maintain a high concentration of salt in the electrolyte. This point was of especial importance in a cell designed to operate at exceptionally low voltage, which would on that account develop less heat than usual. This higher temperature and the evaporation resulting from the conservation of heat would tend to increase current efficiency and reduce voltage still more. At the same time, it would increase the concentration of caustic soda in the

effluent, thus reducing the cost of subsequent concentration. It was realized that long, thin, flat-sided cells have excessive radiation surface.

7. There should be no diaphragm edges within the cell, as experience showed that such edges would fray off and leave cathode exposed.

8. Bus bar connections to the anodes should be as simple as possible and not exposed to corrosion.

9. Circulation within the cell should be very free and the infeed of brine should be effectively distributed to every part of the cell.

10. The hydrostatic head and rate of percolation should be uniform over every part of the diaphragm.

11. Current leakage through infeed and effluent streams and the walls of the cell should be minimized.

12. Mingling of hydrogen with the chlorine should be prevented as far as possible.

Type "S" Cell

These considerations led to the design of a cell of approximately cubical proportions, as the nearest practicable approach to the shape having the minimum ratio of surface to volume. The anodes were housed in the bottom part of the cell, which was of concrete. They consisted of parallel flat blades of graphite, with their lower ends embedded in a lead slab resting upon the cell bottom, from which they projected vertically upward. They were in two banks, with a space between for circulation. The cathode was formed within a flat rectangular frame of steel "channel" section, conforming to the concrete cell bottom, with rows of parallel cathode fingers projecting inwardly along two opposite sides and adapted to alternate with the anodes. The whole was surmounted by a concrete cover.

This construction, i.e., with the anodes projecting upwardly from the bottom, instead of extending downwardly from the top as in all previous cells, was adopted for the following reasons: First, it eliminated any need for having a part of the graphite extend through space occupied only by chlorine gas, which graphite is of course inactive. Secondly, it makes possible an accurate check of the clearances between the anodes and cathode fingers before the cell was closed by putting on the concrete top. The concrete top and bottom were made quite massive, for better heat insulation. The brine was

supplied through a calibrated orifice in a broken stream directed along the central passage between the two banks of electrodes, in order to set up a circulation at right angles to the natural currents. Thus, the brine would be distributed throughout the cell. The effluent was taken off through a pipe set at such a discharge level that the chamber formed between the cathode and channel frame was at all times nearly filled with the electrolyzed brine. Thus, the percolation was substantially equalized over every part of the diaphragm. The chlorine was taken off through an opening in the concrete top by means of an earthenware pipe connected to a header. The hydrogen was taken off through the rear wall of the channel frame. The cell was provided with a double-walled coil for exchange of heat between the effluent and feed brine. The external cathode walls were covered with heat insulation. This cell, now known as the Hooker type "S" cell, is covered by U. S. Patents No. 1,862,-245 and 1,866,065—others pending.

The first of these cells was constructed and put in operation in 1929. It was apparent from the beginning that it would be efficient as to power and economical as to cost of installation, maintenance and operation. It was compact (occupying as little as 70 sq.ft. of floor space per cell, including aisles), and operated at a relatively low voltage and high current efficiency, producing caustic soda of the high concentration of 135 grams per liter. About the only changes since made have

been in the way of leaving off refinements not found to be essential.

The accompanying schematic drawing is arranged, for simplicity, to show all essential details of the Hooker type "S" cell in one view. Other illustrations show the cathode with freshly deposited diaphragm, and a cathode in position upon an anode assembly, with the cover not yet in place. In the illustration all the cells are arranged in double rows of cells placed back to back. The chlorine and hydrogen headers are placed at the rear and above the cells. The brine-feed and caustic effluent headers are placed in front of and below the cells. In this arrangement the outer rows face the side walls of the cell house. An alternative arrangement is to place two single rows of cells with their backs to the side walls of the cell house. This is more economical of floor space, but not quite so neat in appearance.

The voltage at which a given cell will operate depends, of course, upon the current forced through it. Any cell can be operated at any voltage, within practical limits, above the decomposition voltage of the salt, which for sodium chloride is generally accepted as 2.3; but most cells, if operated at low voltage, will show a low current efficiency. The problem is to produce a cell which will operate at low voltage and, at the same time, show a high current efficiency. This has been accomplished in the present instance by incorporating in one cell, in as high a degree as possible, all the features

A circuit of type "S" cells in a plant of the Hooker Electrochemical Co. Note that chlorine and hydrogen headers are placed in the rear and above the cells while the brine and caustic soda headers are in front and below

enumerated which are known to make for high efficiency. This type "S" cell was designed for 6,000 amperes. It may be operated efficiently at 5,000 to 7,000 amperes. The most economical load depends upon the cost of power, materials and construction at different times and localities. Typical operating results with these cells are as follows:

Current, amperes.	5000	6000	7000
Volts	3.28	3.35	3.45
Temperature of effluent, deg. C.[1]	85	90	92
Caustic soda per liter of effluent, grams	135	135	135
Lb. of equivalent chlorate per 1,000 of NaOH	2.5	2.0	1.8
Current efficiency, per cent......	94	95	95.5
Voltage efficiency, per cent[2]......	70	69	67
Power efficiency, per cent.......	66	65	64
Anode life, days.	600	450	350
Diaphragm life, days	250	200	175
Lb. caustic soda per cell per day	373	452	530
Lb. caustic soda per cell per day per sq.ft. of floor space[3]....	53.2	64.6	75.8
Lb. chlorine per cell per day...	330	400	470
Lb. chlorine per cell per day per sq.ft. of floor space[3]	47.2	57.2	67.1

[1] When supplied with heated brine.
[2] Assuming a theoretical decomposition voltage of 2.3 volts.
[3] Including all aisles.

It should be understood that the above results are those obtained when operating the cells under proper control at constant current, the voltage varying from a minimum when the diaphragm and anodes are new to a maximum when the diaphragm and anodes are old. The average voltage depends somewhat upon arbitrary maximum voltage at which the anodes are considered to be used up. The average voltages given in the table are those realized in the Hooker company's plants.

It should also be noted that the deposited type of diaphragm gives chlorine of remarkable purity and freedom from hydrogen. In addition, because there are so few unsubmerged joints and connections, the cell can be run with no infiltration of air and hence the chlorine concentration is exceptionally high.

Operating Details

Still higher current efficiencies can be obtained by increasing the feed of brine and producing caustic soda of lower concentration than that stated, but evaporation costs are then higher. The feed of brine to the cells is controlled by the head upon the brine-feed orifices. As all the orifices in a circuit of cells are supplied from a common source, the caustic soda concentration of an entire circuit of cells can be controlled by regulating a single float valve. In practice, it is found most economical to regulate the feed of brine so that about 55 per cent of the salt is decomposed in passing through the cell.

The useful life of the graphite anodes depends upon the current at which the cell is operated and the temperature and salt content of the brine supplied to it. It also depends, of course, upon the thickness of the anodes when first installed. This is a matter of cell design. However, if they are thick at the start, there will be a correspondingly great variation in the distance between electrodes as the anodes become worn. This condition is not favorable for the highest efficiency or economy. Similarly, the useful life of the diaphragm depends upon the weight of asbestos used per diaphragm. However, a very thin diaphragm, although it will operate for a longer time and at lower voltage than a thicker diaphragm before renewal becomes necessary, will nevertheless not give the best current efficiency. The concrete bottoms last several years and the tops even longer, and the cost of replacement is a very minor item. The steel cathodes represent the largest item in the cost of the cell and these last almost indefinitely.

It may be said that cells of several types having the leading characteristics of the above described cell, but without concrete in their construction, have been built and operated. The results, as might have been expected, were inferior to those given above.

Conclusions

A final comparison of cells is not to be made on the basis of technical results alone, but rather on the basis of total cost, including interest, depreciation, power, maintenance, labor and overhead, not only for the electrolytic system, but also for the evaporation system in which the product is concentrated, divided by tons of product. This brings into the calculation the concentration of the product as it comes from the cells, which is an important factor. Also, since the quantity of product is effected by the current efficiency of the cell, it brings in cell efficiency, which is another important factor. As this calculation obviously depends upon local conditions, it cannot be given here. Suffice it to say that, upon the basis of quality and overall cost per unit of product, this cell compares favorably with other diaphragm cells. Also, after purification of the product by recrystallization to remove small amounts of salt and metals, the cost of the resulting high-grade product compares favorably with that of product of similar quality made by the best mercury cells.

A large number of cells in an attractive back-to-back arrangement at the plant of one of the companies who license the Hooker cell from the Hooker Electrochemical Co. An alternative arrangement in which single rows of cells are placed with their backs to the cell house walls instead of to each other is sometimes used
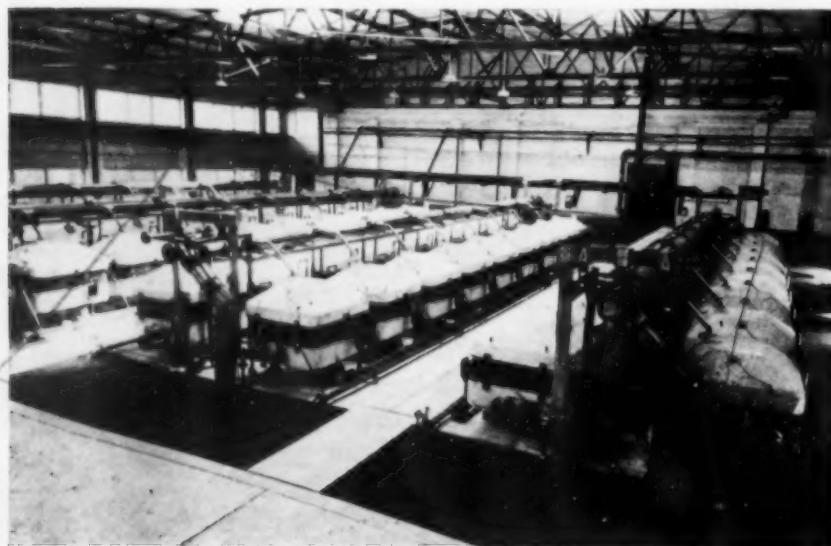
Heat Transfer in Recuperators

It is not always recognized that the thermal conductivity of tube materials used for heat exchange between gases has a considerable influence on the heat transfer rate obtained. What the effect is has been determined theoretically and graphed for ready use.

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As HAS RECENTLY been emphasized by LaQue and Rolle (*Chem. & Met.*, Aug., 1937, pp. 438-41), proper regard has often been lacking for the thermal conductivity and thickness of the material used as the heat transfer medium in heat exchange equipment. It is held by some that within the limits of commercial conditions, the conductivity is of no practical importance, while others have felt that this condition is primary. Although in the reference an excellent discussion and set of curves have been given for the relatively high heat flow rates between liquids, condensing and non-condensing, no mention has been made there of the large class of heat exchangers with low rates of heat transfer such as prevail between two gases, for example, recuperators.

The present paper, which deals primarily with heat transfer by convection, will attempt to cover this omission by including data on certain refractory materials commonly used in the separating wall at moderate and elevated temperatures. A common type of tubular recuperator will be used as an example, with air flowing inside and hot flue gases passing across outside the tubes. The basis of all calculations is 1 sq.ft. of internal tube surface.

The rate of convection heat transfer between two fluids in an exchanger is represented by the following basic formula:

$$U = \frac{1}{\frac{1}{h_1 A_1} + \frac{L}{K_2 A_2} + \frac{1}{h_3 A_3}} \quad (1)$$

where

U = overall heat transfer coefficient in B.t.u. per hour, deg. F. and square foot of internal surface.

h_1 = internal film coefficient in B.t.u. per hour, deg. F. and square foot of internal surface.

A_1 = internal surface in square feet.

K_2 = Thermal conductivity of partition in B.t.u. per hour, deg. F., square foot of mean conducting surface, and foot of thickness.

A_2 = mean thermal conducting surface in square feet.

h_3 = external film coefficient in B.t.u. per hour, deg. F. and square foot of external surface.

A_3 = external surface in square feet.

L = thickness of partition in feet.

Working with an elementary section of 4-in. I. D. tube (Fig. 1) of length in feet y such that the internal heating surface area is A_1, the internal diameter D_1 is 4/12 or 1/3 ft. Using the arithmetic mean for the heat conducting surface (since the percentage deviation from the log mean is unimportant under the assumed conditions), the diameter of the heat conducting surface is $D_1 + L = 1/3 + L$ ft.; and that of the external heating surface, $D_1 + 2L = 1/3 + 2L$ ft. Then $A_1 = \pi y D_1$ and y

Fig. 1—Simple tube section

= $3/\pi$. Since for a given tube y is the same for all three surfaces (disregarding the length of the tube held at its ends in the supporting walls or tube sheets),

$$A_2 = \pi y D_2 = 3(D_1 + L) = 1 + 3L \quad (2)$$

$$A_3 = \pi y D_3 = 3(D_1 + 2L) = 1 + 6L \quad (3)$$

Substituting values (2) and (3) in Equation (1) we obtain:

$$U = \frac{1}{\frac{1}{h_1} + \frac{L}{K_2(1 + 3L)} + \frac{1}{h_3(1 + 6L)}} \quad (4)$$

for a 4-in. I.D. tube of thickness L ft.

To compare the overall coefficients for various materials and thicknesses, h_1 and h_3 have both been taken equal to 9 B.t.u. per hour, square foot and deg. F., for one set of calculations and curves; and to 5 such units for another, as shown in Fig. 2. The first of these values may be considered an upper limit under practical operating conditions as it yields overall heat transfer rates in the general region of 5, and the latter is more nearly an average since the overall coefficient with it works out to around 3 (Trinks, "Industrial Furnaces," Vol. 1 [3d ed.], p. 203).

Thus, as inspection of Equation (4) and Fig. 2 shows, two separate families of curves are produced for the materials studied, in which the only variables affecting U are the thermal conductivities and the thicknesses, L, of the walls. When the individual surface coefficients are 9, U is 4.5 for zero thickness; and at 5 for h_1 and h_3, $U = 2.5$ if $L = 0$.

Corresponding curves have been worked out for 3-in. and 6-in. I.D. tubes with results showing the same form, as appears in Figs. 3 and 4.

Fig. 2—Relation of thickness of tube wall to overall heat transfer coefficient for a 4-in. I. D. tube. Six different heat conducting materials are compared at two different fluid film coefficients

In the accompanying table are given the conductivities and the equations of the curves of Fig. 2 for the materials considered. As a matter of purely theoretical interest, equations also were developed for an imaginary material having no thermal resistance (infinite conductivity) in order to compare the available substances with an ideal one under recuperator conditions. With surface coefficients of 5, the curve for the perfect conductor does not differ from that for copper up to 2-in. thickness; and the same is true up to 1-in. thickness when the individual values are 9. In this latter case, however, between 1- and 2-in. thickness the ideal material shows a slight increase in U above that for copper, as indicated by the dotted line in this region.

In considering the curves, it is first of all evident that for zero thickness and any one pair of surface coefficients, U is the same for all materials, ideal or otherwise. With finite thickness, however, the different curves are markedly affected by the conductivities when the latter are low. But the interesting fact appears for materials of medium to high conductivity that within commercial limits there are comparatively small percentage or actual changes in heat transfer rates with different wall thicknesses and constant individual surface coefficients. Furthermore, there is only a small increase in U for a tube of highly conducting metal such as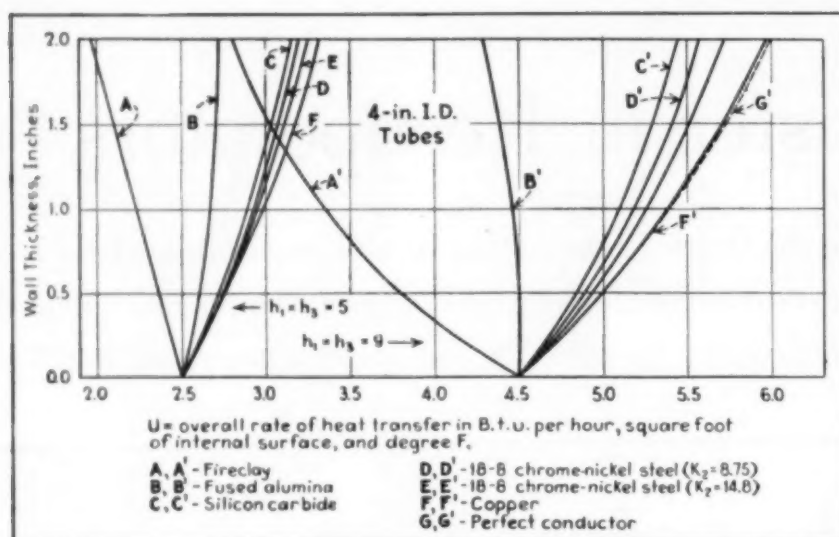 copper over one of silicon carbide provided the same thicknesses are used in both. This same statement is true if the resistance to heat passage is assumed to be zero.

Another curious point brought out

by the curves is that contrary to what might be expected, increasing the wall thickness with good conductors very definitely raises the heat transfer rates. (This phenomenon is discussed in detail in engineering texts such as Walker, Lewis and McAdams' "Principles of Chemical Engineering," 1st ed., p. 127.) This leads to the most striking feature of all, which is that with any metal tube 0.3 in. thick or less, for example, U is consistently less than is the case for a silicon carbide tube of, say, $7/8$-in. thickness, or more.

In connection with the foregoing it is noteworthy that a tube of a material of intermediate heat conductivity such as fused alumina has a fairly constant U for all commercial thicknesses. But a poor conductor like fireclay shows a decidedly decreasing U with increasing thickness.

A possible objection to thicker walled tubes lies in the fact that if the same areas between tubes are maintained as for thin walls, the former will require a larger housing. This is to a certain extent true, but not enough so to necessitate any marked change in overall dimensions of recuperators. One of the primary requirements of these heat exchangers is accessibility for cleaning. Involved in this factor is the tendency of metal tubes to sag or warp under long continued heating. Unless reasonable clearances are provided between them, they are apt in course of time, to move out of alignment so much as to prevent insertion of cleaning tools. Thus it grows continually more and more difficult to eliminate plugging of the gas passages unless by sound design ample room has originally been allowed. But since thick walled tubes are more resistant to sagging and warping within proper temperature limits,

Conductivities and Heat Transfer Coefficient Equations for Materials Considered in Fig. 2

| | THERMAL CONDUCTIVITY | | EQUATIONS OF CURVES IN FIG. 2 | |
MATERIAL	Per Inch	Per Foot (K_2)	When Surface Coefficients = 9	When Surface Coefficients = 5
Fireclay	7.05	0.5875	$U = \dfrac{0.081881 + 0.736933\,L + 1.473866\,L^2}{0.018196 + 0.248548\,L + L^2}$	$U = \dfrac{0.072397 + 0.651571\,L + 1.303142\,L^2}{0.028059 + 0.296981\,L + L^2}$
Fused alumina	20	1.667	$U = \dfrac{0.178571 + 1.607143\,L + 3.214285\,L^2}{0.039683 + 0.345238\,L + L^2}$	$U = \dfrac{0.138889 + 1.25\,L + 2.5\,L^2}{0.055556 + 0.416667\,L + L^2}$
Silicon carbide	80	6.667	$U = \dfrac{0.344828 + 3.103448\,L + 6.206896\,L^2}{0.076628 + 0.511494\,L + L^2}$	$U = \dfrac{0.222222 + 2.0\,L + 4.0\,L^2}{0.088889 + 0.566667\,L + L^2}$
18–8 Stainless steel [1]	105	8.75	$U = \dfrac{0.372340 + 3.551062\,L + 6.702123\,L^2}{0.082742 + 0.539007\,L + L^2}$	$U = \dfrac{0.233333 + 2.1\,L + 4.2\,L^2}{0.093333 + 0.586667\,L + L^2}$
18–8 Stainless steel [2]	177.6	14.8	$U = \dfrac{0.414845 + 3.733602\,L + 7.467203\,L^2}{0.092188 + 0.581156\,L + L^2}$	$U = \dfrac{0.249662 + 2.246962\,L + 4.493924\,L^2}{0.099865 + 0.616059\,L + L^2}$
Copper	2640	220	$U = \dfrac{0.493273 + 4.439461\,L + 8.878922\,L^2}{0.109616 + 0.659940\,L + L^2}$	$U = \dfrac{0.275689 + 2.481205\,L + 4.962409\,L^2}{0.110276 + 0.662908\,L + L^2}$
Material having no thermal resistance	∞	∞	$U = \dfrac{4.5 + 27\,L}{1 + 3L}$	$U = \dfrac{2.5 + 15\,L}{1 + 3L}$

[1] LaQue and Rolle, loc. cit.   [2] Martin, Thesis on Physics, Mass. Inst. Tech., Cambridge, Mass., 1929.

the center-to-center distances between them depend only on the practical problems of manufacture and assembly and on the area required in the space outside the tubes for the gases to flow, provided suitable space for cleaning the passages has originally been allowed.

The practical working out of the problem in a typical case shows that, for a given area outside of tubes 4-in. I.D. by 4½-in. O.D. for metal, and 4-in. I.D. by 5⅞-in. O.D. for silicon carbide of identical length and the same number of both kinds of tubes, the housing would be about 10 per cent smaller in width and 16 per cent less in height for metal. But when it is remembered that slightly fewer silicon carbide tubes would be called for, other conditions being equal, and that provision for cleaning must be kept in mind, the final result is that if the same brick and insulation thicknesses are adhered to, there is no essential difference in space requirements of the two.

Mention should also be made of the effect of clearances between tubes on heat absorption due to radiation, although that is really beyond the scope of this paper. It is, of course, well known that recuperators transmit much heat due to the radiating power of the CO_2 and water vapor of the flue gases and that the thicker the gas layer the greater the coefficient of heat transfer due to this property. If tubes are located too closely together, some efficiency of heat transmission is sacrified which must be compensated for by an increase in tube surface. Consequently it is evident that where flue gas temperatures are high enough to allow radiation to become an important feature (above about 800 deg. F.), it is generally better to use relatively short tubes with greater center to center distances than long tubes with narrow clearances that would furnish the same effective area for the gases. This principle is corollary to Trinks' opinion (*loc. cit.*, p.

199), based on the radiating power of CO_2 and water vapor and the lack of this in nitrogen and oxygen: "The best design of recuperator, therefore, from a heat transfer standpoint, is that in which the flue gases travel slowly in large passages, while the air is passed through at high velocity."

The above remarks are especially true for the larger overall rates of heat transfer, indicated by the family of curves at the right of the several charts. As pointed out by Trinks, however, figures as high as these are seldom obtained in recuperator practice. He believes that around 2.5 is more nearly representative. Consequently, the curve groups at the left of the charts were plotted. These show that the same observations apply at average heat transfer rates in recuperators, but the differences between the various materials are somewhat less in degree. In other words, from the standpoint of heat exchange alone in recuperator tubes of 3-, 4- and 6-in. inside diameter at the same mass flow rates:

1. The thicker the tube wall the greater the rate of heat transfer, provided a material of a thermal conductivity of more than about 1.667 B.t.u. per hour, square foot, deg. F. and foot of thickness is used.

2. For the same commercial tube thicknesses (up to about 1 in.) there is very little percentage or actual increase in overall heat transfer from using any ordinary metal rather than a material such as silicon carbide with a conductivity of 6.67 to 9.0.

3. For tube thicknesses employed in practice (⅞ in. for silicon carbide and up to 0.3 in. for metal), the silicon carbide tube shows the greater overall rate of heat transfer.

The explanation of the foregoing is that the increase in the external heating surface with the larger outside diameter more than compensates for the greater thermal resistance of the material that results from the greater thickness, as long as the conductivity is greater than about 1.667 B.t.u. per hour, square foot, deg. F. and foot of thickness, and provided that the overall heat transfer rate does not exceed approximately 5 B.t.u. per hour, square foot and deg. F.

In conclusion the author wishes to acknowledge the helpful criticism of this paper which has been received from Prof. W. Trinks, Carnegie Institute of Technology, and from members of the technical staff of The Carborundum Co.

Fig. 3 (upper) and Fig. 4 (lower)—These curves show for 3-in. I. D. tubes and 6-in. I. D. tubes the same relationships as are shown for 4-in. I. D. tubes in Fig. 2

A, A' - Fireclay
B, B' - Fused alumina
C, C' - Silicon carbide
D, D' - 18-8 chrome-nickel steel (K_2 = 8.75)
E, E' - 18-8 chrome-nickel steel (K_2 = 14.6)
F, F' - Copper
G, G' - Perfect conductor
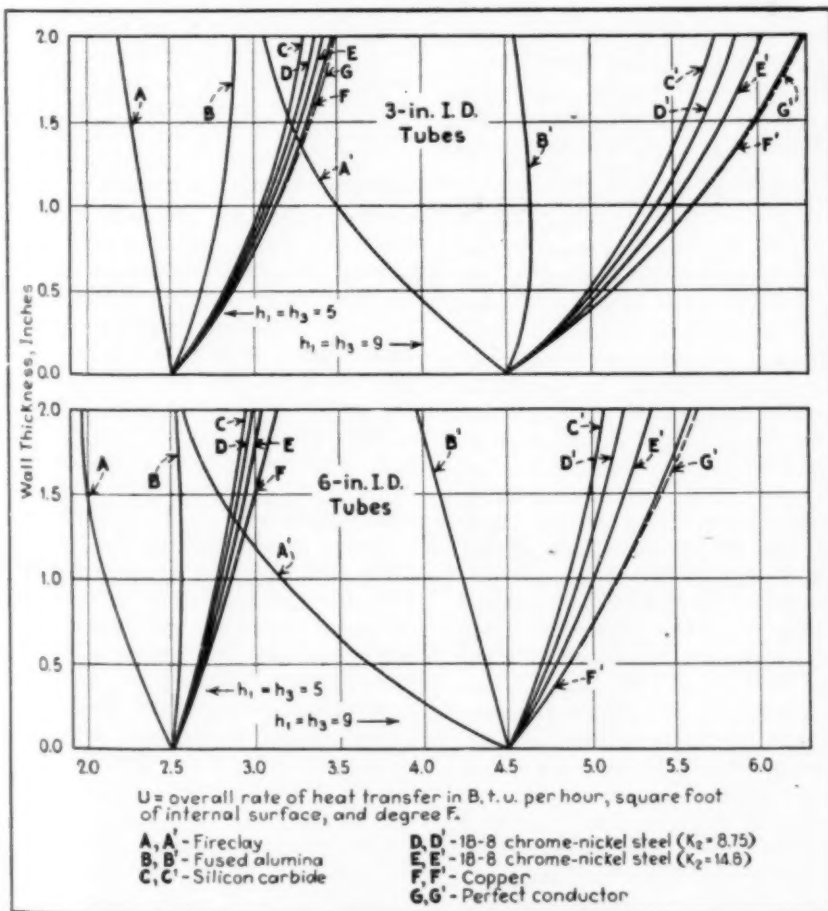
Utilization of Light Hydrocarbons

Pumping 16,500 barrels per day of light hydrocarbons from East Texas oil fields through a 300-mile pipeline for superfractionation and polymerization in the world's largest thermal polymer plant provides some interesting problems which are discussed from a chemical engineering point of view in this article.

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BUTANE has long been the key hydrocarbon in the control of gasoline volatility and the operation of light hydrocarbon recovery equipment, in that, while its recovery for inclusion in gasoline has been economically desirable, its inclusion has been limited by maximum allowable gasoline vapor pressure. Consequently, while in the past most of the butane recoverable in the petroleum refining industry has been utilized, some has been burned as fuel, with an appreciably lower return to the refiner, or wasted altogether. Recent increases in the recovery of natural gasoline in the producing fields and, of more importance, in the production of cracked gasoline, which has approximately doubled in the last six years, have increased considerably the quantities of butane recoverable. As a result the amounts that cannot be utilized in gasoline, and hence are burned as fuel or wasted, have increased enormously. Concurrently, much progress has been made in the field of the conversion of hydrocarbon gases by polymerization processes into liquid hydrocarbons that are useable in gasoline because of their relatively low volatility. In general, the development of these processes has been such that polymerization of the heavier gases seems more economically attractive than of the lighter ones. For this reason, commercial developments for such conversion of butanes and propanes, the latter not being useable at all in gasoline, have been quite rapid. This paper de-

scribes the developments in this field recently completed by the Humble Oil and Refining Co. in East Texas and at its Baytown refinery for the conservation and utilization of such light hydrocarbons. It is believed that an account of these developments is worth while in that several units in the project are unique, and in that all steps of the development have been made on an unprecedented scale.

The principal elements of this development are shown schematically in Fig. 1. The numerical values shown on this diagram must be regarded as approximate averages, and have been included only to give some idea of the scale of operations. Variations due to seasonal trends and other factors result in quantities during certain periods quite different from those shown. A supply of about 9,500 bbl. per day of butanes was developed in East Texas by expansion of the Company's own recovery facilities, and by purchase from others. These butanes, with varying amounts of propane, are blended with natural gasoline to reduce vapor pressures to a maximum of about 60 lb. Reid vapor pressure at 100 deg. F., and the mixture is brought to Baytown by pipe line. A portion of the butane is used as charge to a thermal polymerization plant, while the remainder is used to blend gasoline shipments to maximum allowable vapor pressures. Therefore plant recovered butanes formerly used for

this purpose are released for charge, along with the first-mentioned portion of the field butanes, to the thermal polymerization plant.

Butanes recovered from refinery operations are passed through a sulphuric acid co-dimer plant before charging to the thermal polymerization plant, since a higher return is effected by conversion of the unsaturates to co-dimer than by charging them to the thermal polymerization plant. This co-dimer plant, however, is somewhat independent of the main project under discussion. Even in this brief description of the operations as a whole, attention should be called to the superfractionation employed to separate field butane isomers, allowing isobutane to be used principally as charge to the thermal plant and normal butane to be used in gasoline blends, and to separate isopentane from the debutanized field casinghead gasoline. In addition to the pipe line and processing units, pressure storage for the volatile products had to be provided both between processing operations and before shipment. The design and operation of each of these is discussed in some detail below.

An 8-in. pipe line approximately 300 miles long, carrying a mixture of natural gasoline and excess butanes and propane having a Reid vapor pressure between 40 and 60 lb. from a gathering station near New London, Texas, to Baytown, was put into operation in July, 1936 by the Humble Pipe Line Co. A considerable portion of the line was provided by converting an existing crude pipe line into this service. As originally installed, the only pump station was

Table I—Salient Features of Fractionating Towers

	Column I	Column II	Column III Isopentane Tower	Column IV Butane Fractionator
	Depropaniser	Debutaniser		
Diameter ft.	8.0	10.5	7.0	8.5
Height, ft.	111	103	120	111
Number of trays	45	40	50	45
Safe working pressure	275	100	50	120
Reflux/overhead (design)....	12.8	2.6	15.5	10.3

at New London, Texas, and a capacity of about 11,000 bbl. per day was obtained with 700 lb. discharge pressure. Two 8-stage centrifugal pumps, connected through speed increasers to 300 hp. gas engines, were employed, one of these being a spare. Subsequently, a booster station was put in operation at Hearne, midway between New London and Baytown, increasing the capacity of the line to approximately 15,000 bbl. per day. Additional temporary booster stations were later installed at points midway between New London and Hearne and between Hearne and Baytown, increasing the line capacity to about 19,000 bbl. per day. Additional natural gasoline from Humble plants in the Conroe and Tomball fields is introduced into the main line at Satsuma, the location of the last booster station.

At both New London and Baytown, the entire stream is metered through displacement meters. Means are provided at each point for careful and frequent calibration of the meters, and in these calibrations it is usual for a meter accuracy of 0.1

per cent to be obtained. Continuous vapor pressure recorders have been installed and are in operation at both the New London and Baytown ends of the line.

An unusual feature of this system is that no storage is provided along this line between New London and Baytown, each of the booster stations operating without the benefit of storage or surge tanks.

Equipment for rectification of the pipe line propane-butane-casinghead stream was put into operation in the spring of 1937. A view of the columns is shown in Fig. 2.

Fig. 2—Superfractionation columns towering 120 ft. in the air rectify casinghead gasoline and separate isomers

Superfractionation Plant

In the first column, propane and lighter fractions are removed, with provision for taking a highly purified propane side stream from near the top for sale as bottled gas or for use at a propane lube treating plant. In the second column, the total butane cut is taken overhead. A portion of the bottoms from this tower is charged to a third tower for removal of isopentane. In the fourth tower the butanes taken overhead from the second tower are divided into iso and normal fractions. The plant also includes two other towers which are used in similar operations on plant-recovered light ends. Principal data on the fractionating towers mentioned are given in Table I.

A typical composition of the feed stock is as follows:

	Liquid Volume, Per Cent
Propane and lighter	8.8
Isobutane	11.9
n–Butane	42.0
Isopentane	11.3
n–Pentane	10.6
Heavier	15.4
	100.0

The outstanding feature of this equipment is the high purity of products obtained on an operation of such

Fig. 1—An outline of the path of 16,500 bbl. per day of crude hydrocarbon gas from East Texas gas fields as it travels through superfractionation unit, thermal polymer co-dimer and plant to be made into gasoline for motor fuel

Table II—Product Analyses, Superfractionation Unit

Tower	Charge Bbl. per Day	Impurities in Overhead, Per Cent	Impurities in Bottoms, Per Cent
1	10,450	C_4, 0.96	C_3, 0.0
2	10,160	C_5, 3.4; C_3, 0.0	C_4, 0.0
3	2,266	nC_5, 0.0; C_4, 0.0	iC_5, 0.2
4	2,900	nC_4, 0.7; C_3, 0.0	iC_4, 0.3; C_5, 0.4
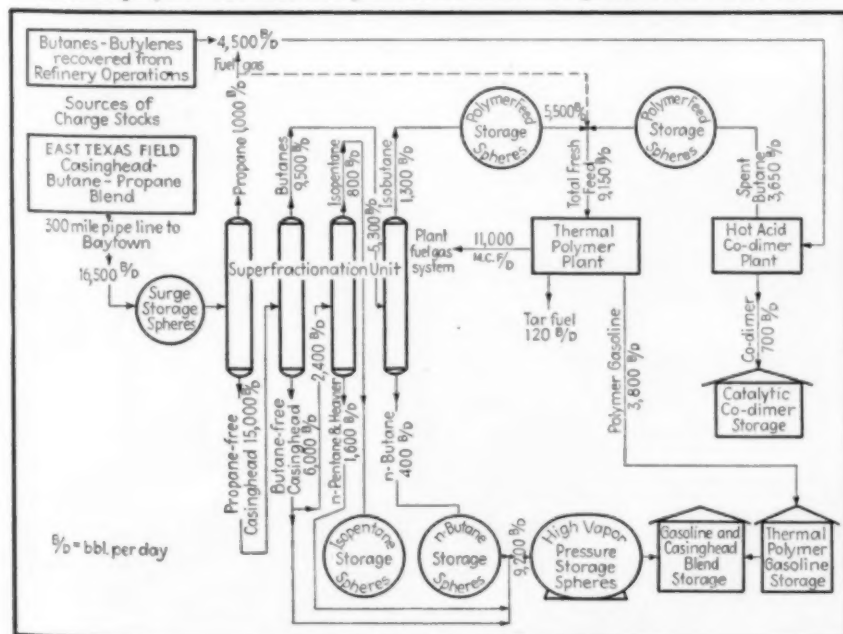
a large scale. Analyses of products obtained during a test run are shown in Table II.

Thermal Polymerization Plant

In this plant, the so-called Unitary process is employed, the light hydrocarbons being cracked and polymerized simultaneously in a coil at a temperature of about 1,025 deg. F. and a pressure of about 1,800 lb. at the heater outlet. Fig. 3 shows a general view of the plant.

The equipment was designed to charge 6,700 bbl. per day of fresh feed with a total feed of 27,600 bbl. per day through the coil, producing 3,260 bbl. per day of polymer gasoline. However, fresh feed rates up to 10,000 bbl. per day, with a production of 3,500 bbl. per day of polymer gasoline, have been realized by discarding to residue gas a portion of the propane produced in the reaction, which the design contemplated recycling. Recycling of maximum quantities of propane or the inclusion of propane in the fresh feed is economical only when there is insufficient butane to run the plant at full capacity. Furnace charge rates of 38,000 bbl. per day have been realized. A conversion of 16.7 per cent by weight (to total liquid product of 10 lb. R.v.p.) was contemplated in the design, and this is being met very closely in current (March 1938) operations.

Principal features of the unit are shown in the flow diagram, Fig. 4. The coil discharge stream, after being cooled in transfer line exchangers and a water cooler, enters a primary tower operating at 400 lb. pressure, where butane and lighter fractions are taken overhead and polymer gasoline is withdrawn as bottoms. This latter stream enters the gasoline tower, operating at atmospheric pressure, where light polymer gasoline is taken overhead, heavy polymer gasoline is withdrawn as a sidestream, and heavy polymers and cycle stock for quenching the transfer line exchangers are withdrawn as bottoms. The overhead from the primary tower enters the furnace feed stripper along with the fresh feed, where the butanes, and any of the propanes that it is desired to recycle, are taken as bottoms, lighter fractions coming overhead. The overhead stream passes to refrigeration equipment where further propane may be recovered for recycling when desired. Representative product inspections and stream analyses are given in Tables III

Table III—Product Inspections, Thermal Polymerization Unit

	Light Polymer Gasoline	Heavy Polymer Gasoline	Gas Oil and Tar
Gravity, deg. API	75	44	20
Initial boiling point, deg. F.	90	195	370
Final boiling point, deg. F.	245	450	90% @ 660° F.
Per cent over at 158 deg. F.	58	....	....
Per cent over at 212 deg. F.	95	2–3	....
Reid vapor pressure, lb./sq.in.	13	2–3	....
Octane number, C.F.R. (clear)	77.5	75.0	....
Octane number, C.F.R. (blending value*)	87.0	....	....

* When blended to a 30 per cent mixture with 65 octane number reference fuel.

and IV, above and on page 365.

The furnace was designed for a heat liberation of 132,000,000 B.t.u. per hr. and efficiency of 61 per cent, temperatures of oil entering and leaving being about 615 deg. F. and 1,025 deg. F. respectively. The preheater and radiant sections in the furnace proper contain 7,140 sq. ft. of outside tube surface; tubes are 40 ft. long, 5 in. O.D. with a ¾-in. wall thickness. In a separate setting and heated only by flue gases from the fired furnace is the soaking section, which contains 13,448 sq. ft. of surface, the tubes being 5½ in. O.D. and 9/16 in. thick. All tubes, other than those in the first part of the preheater, are of a 2 per cent Chrome and 0.5 per cent Moly composition. The total feed is pumped through the furnace by two single-stage double-acting quintuplex pumps, operating in parallel, each driven by a single-tandem, horizontal four-cycle, double-acting gas engine with a 25-in. bore and 36-in. stroke, rated at 825 hp. at 138 r.p.m.

Exchangers for the transfer line are thought to be an unusual feature of the equipment. The first set of these must handle the furnace discharge stream at a pressure of 1,900 lb. and a temperature of 1,000 deg. F. Together, all the transfer exchangers preheat the furnace charge to an inlet temperature of about 615 deg. F., recovering almost as much heat as is added in the furnace. Average heat transfer rates of about 180 B.t.u. per hr. per deg. F. per sq. ft. are realized. The exchangers consist of 8.15-in. O.D. tubes, constituting shells, each of which contain four 2⅜-in. O.D. tubes in parallel. The flow is countercurrent throughout. To facilitate cleaning, the furnace discharge stream flows inside the small tubes with the furnace feed stream on the outside.

Storage of Volatile Fractions

Two 2,500-bbl. spheres, built for 100 lb. safe working pressure, were installed at the refinery end of the pipe line to act as surge drums before the rectification plant. These proved inadequate in capacity to insure smooth operation, and an additional 5,000-bbl. sphere was added.

Fig. 3—A general view of the world's largest polymerization plant where as much as 3,500 bbl. per day of polymer gasoline is made by the Unitary process

Three 12,500-bbl. spheres, built for 50 lb. safe working pressure, were installed for storage of field and refinery butanes cut at the rectification plant to be fed to the thermal polymerization plant or blended into finished gasolines. Because of an increase in the volume of materials to be handled, this storage has been increased to five spheres, providing a total capacity of 62,500 bbl.

Since the refinery acts as a terminal for the 18-lb. natural gasoline brought through the pipe line with the excess butane and propane from the East Texas field, considerable storage is necessary for this material. Three 80,000-bbl. spheroid tanks, two good for 15 lb., the third for 10 lb. gage safe working pressure, have been installed. The refinery already had in service two 80,000-bbl. insulated and refrigerated tanks for casinghead storage, so that storage is available for 400,000 bbl. of casinghead of Reid vapor pressure up to about 32 lb. Insulated and refrigerated storage was installed a number of years ago in preference to pressure storage primarily because spare tankage was then available, which allowed the casinghead storage to be provided at only the cost of insulation and the installation of vapor recovery facilities. Current operations indicate that the above storage is inadequate, and construction of two additional 80,000-bbl. spheroids is planned, bringing the total storage available for 32-lb. products up to 560,000 bbl.

Forced Draft Cooling Tower

Cooling water for both the thermal polymerization and superfractionation plants is provided by a forced draft cooling tower. The tower is 237 ft. long, 56 ft. wide, and 36 ft. high, and is divided into 28 cells, each equipped with a 20-hp., 1,750-r.p.m. electric motor, geared to drive a fan at a speed of 350 r.p.m. There are approximately 1,500 spray nozzles in the entire installation. With all cells in operation, the tower is designed to cool 21,000 g.p.m. of water from 120 deg. F. to 85 deg. F., at a wet bulb temperature of 80 deg. F. The circulating system is of the closed type; the water is pumped from the pit of the tower through the equipment and back over the tower with one set of pumps. Pumping equipment consists of four units: two motor-driven, one steam-driven, and one dual-driven, each rated at 7,500 g.p.m. against a 180-ft. head.

Table IV—Typical Stream Analyses

—Analysis—Mol. Per Cent—

Constituent	Fresh Feed	Furnace Feed	Residue Gas
C₁	.....	.....	51 0
C₂	.....	1.5	28.0
C₃	.....	10.5	19.5
i-C₄	20.0	30.0	} 1.5
n-C₄	80.0	58.0	
Total	100.0	100.0	100.0
Unsaturates	15.0	14.0	12.0
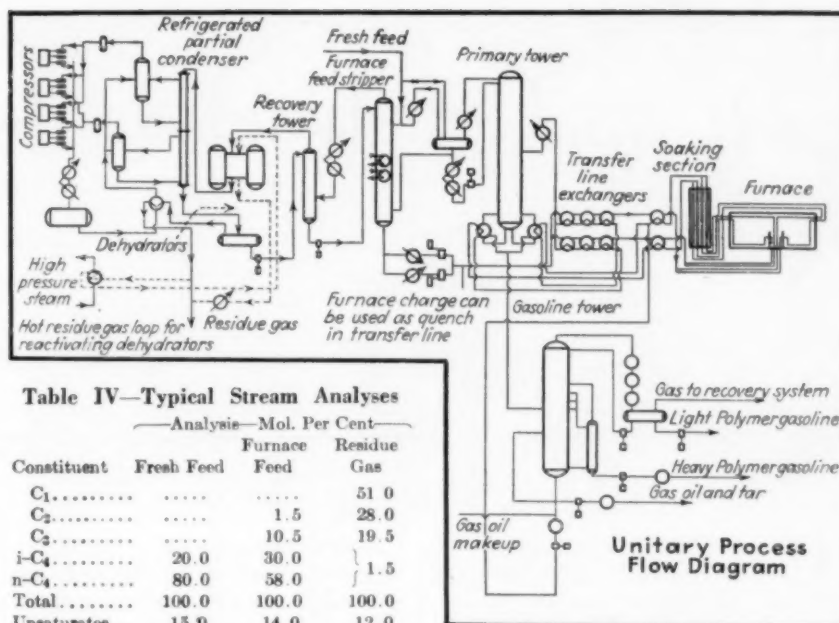
Fig. 4—Flow diagram and typical gas stream analyses of the thermal polymerization plant of the Humble Oil and Refinery Co.'s plant at Baytown,

Status of Chemical Raw Materials Of Major Powers

The U. S. A. stands at the top of the list of major powers having a sufficient production of chemical raw materials for warfare purposes, according to Dr. Ernst Berl of Carnegie Institute of Technology. Among the most important warfare raw materials are gasoline and diesel oil, and the United States produces more than 60 per cent of the world's crude oil—over a billion bbl. per year (statistics for 1936 from "Petroleum Facts and Figures, 1937"). Next in volume of production comes U.S.S.R. with 215,578,000 bbl.; then Venezuela, Rumania, Iran, Dutch India, Mexico, Iraq, and a number of other lesser powers. Production among the major powers is as follows: Great Britain, 33,000,000 bbl.; Germany, 3,080,000; Japan, 2,000,000; France, 532,000; Italy, 150,000. It is estimated that a major power engaged in a general conflict requires roughly from 60 to 90 million bbl. of oil products per year.

Dr. Berl, after a careful analysis of the foreign situation has compiled the following table showing the relative position of the major powers in the production of these essential raw materials:

Will These Nations Be Self-Sufficient in Chemical Raw Materials in Wartime?

	United States	Great Britain	U.S.S.R.	France	Germany	Italy	Japan
Rubber	Partly	Yes	No	Partly	No	No	No
Nickel	Yes	Yes	Partly	Partly	No	No	No
Chromite	Partly	Yes	Yes	Yes	No	No	Yes
Tungsten	Yes	Yes	Partly	Partly	No	No	Yes
Antimony	Partly	Partly	No	Yes	No	Partly	Partly
Tin	Partly	Yes	Partly	Partly	No	No	Partly
Mercury	Yes	No	Yes	No	No	Yes	Partly
Phosphates	Yes	Partly	Yes	Partly	Partly	No	Partly
Wool	Yes	Yes	Yes	Partly	Partly	Partly	No
Potash	Yes	Partly	Yes	Yes	Yes	Partly	Partly
Mica	Yes	Yes	Yes	Partly	No	No	Yes
Aluminum	Yes	Yes	Partly	Yes	Partly	Yes	No
Cotton	Yes	Partly	Yes	Partly	No	No	Partly
Lead	Yes	Yes	Yes	Partly	Partly	Yes	Partly
Copper	Yes	Yes	Yes	Partly	Partly	Partly	Yes
Oil	Yes	Partly	Yes	Partly	Partly	No	Partly
Manganese	Yes	Yes	Yes	Partly	Partly	Partly	Partly
Zinc	Yes	Yes	Yes	Partly	Partly	Yes	Partly
Sulphur	Yes	Partly	Yes	Partly	Partly	Yes	Yes
Nitrates	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Iron ore	Yes	Yes	Yes	Yes	Partly	Yes	Partly
Coal	Yes	Yes	Yes	Yes	Yes	No	Partly
SUMMARY							
Sufficient production	18	15	16	7	3	7	
Insufficient production	4	6	4	14	10	5	12
No production	..	1	2	1	9	10	

Drum Construction Is Improved

The new light-weight drum means a potential saving of over a million and a half dollars to chemical manufacturers. Savings will be made in the cost of the drum as well as in freight charges without reducing the utility of the drum.

THE STEEL BARRELS & DRUMS COMMITTEE of the Manufacturing Chemists' Association has been successful in obtaining the approval of the Interstate Commerce Committee and the Consolidated Classification Committee of changes in the specifications for the 18 gage, 55 gallon and the 19 gage, 30 gallon steel drums which are widely used for transporting non-dangerous liquids and other inflammable liquids flashing between 20 deg. F. and 80 deg. F. These changes became effective July 1 and are as follows for the 55 gallon size.

GAGE OF STEEL

	Old Specifications		New Specifications	
	Bodies	Heads	Bodies	Heads
ICC 5E Specification				
55 gal..........	18	18	20	18
Consolidated Classification Committee				
Rule 40 Sec. 5C				
35 gal. 58 gal.	18	18	20	18

This change applies only to bung drums. The open head drums have not been changed.

This new drum weighs 9½ lb. less than the present drum in the 55 gal. size and hence will reduce transportation costs. If the average trip freight is 40 cents per 100 lb. the saving would be 4 cents per drum. The price of the new drum will probably be 20 cents less than the old drum, and as there is a normal production of about 8,000,000 drums of this type annually, the potential saving ($1,-600,000) is indeed very great.

Reasons for Change

This change has been based on two basic facts which were proved by the Committee. In the first place the present drum is a satisfactory container—its transportation record is of the best. Secondly it was found that the drum was unbalanced in strength as the side walls are stronger than the heads. It was therefore logical to reduce the gage of the side walls to more nearly approximate the degree of resistance to abuse which is built into the heads. Twenty gage steel was found to be more flexible than

18 and this has resulted in a greater capacity of the drums to absorb shocks as will be noted by the results of the drop tests.

The Steel Barrels & Drums Committee conducted a series of comprehensive tests to prove their contention. These tests included drums fabricated with 19 gage side walls but as they did not give better results than the 20 gage side walls the recommendation was made for the latter construction.

Several conclusions were drawn from the tests that were made on the new type of drums.

1. The hydrostatic test, the drop test, and the impact test all show that the drums made of 18-gage heads and 20-gage side sheets are entirely safe containers.

2. The drop test clearly shows that drums with 20-gage side sheets can withstand as much if not more punishment of this type than the regular I.C.C. 5E construction.

3. The new drum stood hydrostatic pressure of 36 lb. for 3 minutes with-

Heads of three test drums were bulged beyond the plane of the chimes by the application of a 36-lb. hydrostatic pressure which was maintained for three minutes

A continuation of the hydrostatic test revealed that drum 4A (18 gage) leaked at 83 lb., drum 4B (19 gage) at 78 lb., and drum 4C (20 gage) at 70 lb.

Left—Drop tests are made from 4, 5 and 6-ft. heights to a concrete floor in such a manner that the specimen always lands at an angle. Above—Drums 3A and 3B leaked after a 5-ft. drop, while drum 3C withstood both 4- and 5-ft. tests but leaked at 6

out leaking. The pressure required to cause leakage was 73 lb., which might be compared with the pressure specified under I.C.C. container specification No. 5 of 40 lb. and I.C.C. 5E of 15 lb.

4. On the impact test the all 18-gage drums were somewhat superior to the new 20-gage drum. It will be noted that failure occurred in every instance at the junction of the dent or depression with the depression caused by a previous drop. It is therefore considered that greater resistance to distortion of the 18-gage sheets is responsible for this condition. It will be noted that a 20-gage side sheet drum stood a single drop from a height of 6 ft. without failing, thereby indicating that failure will probably not result unless two dents meet.

Drums of each of the following types were purchased from four

Hydrostatic Tests

Drum Manufacturer	Gage of steel in sidewall	Pressure in lb. at which head distended to plane of chime	Condition of drum at 36 lb. held for 3 min.	Remarks
1	18	7¾	Sound — no leak	Heads ¼ in. below chimes before pressure applied.
2	18	2	Sound — no leak	Heads ⅛ in. below chimes before pressure applied.
3	18	8	Sound — no leak	Heads ½ in. below chimes before pressure applied.
4	18	5	Sound — no leak	Heads ⅜ in. below chimes before pressure applied. (Carried to failure at 83 lb.)
AVERAGE		5.69	All sound	
1	19	7	Sound — no leak	Heads ¼ in. below chimes before pressure applied.
2	19	3¾	Sound — no leak	Heads ⅛ in. below chimes before pressure applied.
3	19	8	Sound — no leak	Heads ½ in. below chimes before pressure applied.
4	19	3	Sound — no leak	Heads ¼ in. below chimes before pressure applied. (Carried to failure at 78 lb)
AVERAGE		5.44	All sound	
1	20	7½	Sound — no leak	Heads ¼ in. below chimes before pressure applied.
2	20	3	Sound — no leak	Heads ¼ in. below chimes before pressure applied.
3	20	7¼	Sound — no leak	Heads ½ in. below chimes before pressure applied.
4	20	5	....	Heads ¼ in. below chimes before pressure applied. (Carried to failure at 70 lb.)
AVERAGE		5.69	All sound	

Drop Test—Measurement of Distortion in Inches

Drum Manufacturer	Gage of steel in sidewall	Drop 4 ft. Length	Width	Drop 5 ft. Length	Width	Drop 6 ft. Length	Width	Leaked after	Remarks
1	18	16 in.	4 in.	21 in.	9 in.	....	....	5 ft. drop	Metal tore 5 in at head of chime.
2	18	18 in.	6 in.	....	....	....	....		Leaked through seam. Probably not properly rolled down.
3	18	17 in.	5 in.	20 in.	9 in.	....	....	5 ft. drop	Leaked through seam.
4	18	18 in.	4 in.	21½ in.	9 in.	....	....	5 ft. drop	Leaked through seam.
AVERAGES		17.25 in.	4.75 in.	20.83 in.	9 in.	....	....	4.75 ft.	
1	19	17 in.	5 in.	24 in.	11 in.	23 in.	14 in.	No leaks	
2	19	18 in.	5½ in.	....	....	....	....	4 ft. drop	Leaked through seam. Probably not properly rolled down.
3	19	16 in.	5 in.	21 in.	10 in.	....	....	5 ft. drop	Leaked through seam.
4	19	18½ in.	6½ in.	....	....	....	....	4 ft. drop	Leaked through seam. Probably not properly rolled down.
AVERAGES		17.4 in.	5.5 in.	22.5 in.	10.5 in.	23 in.	14 in.	4.75+ ft.	
1	20	17 in.	7 in.	22 in.	11 in.	....	....	5 ft. drop	Very slight leak — occasional drop through seam.
2	20	19 in.	6 in.	21 in.	11½ in.	23 in.	16 in.	6 ft. drop	Leaked through seam.
3	20	17 in.	5½ in.	21 in.	11 in.	25 in.	14 in.	6 ft. drop	Seam burst open.
4	20	19 in.	6 in.	....	....	....	....	4 ft. drop	Leaked through seam. Probably not properly rolled down.
AVERAGES		18 in.	6.1 in.	21.3 in.	11.1 in.	24 in.	15 in.	5.25 ft.	

Impact Tests

Drum Manufacturer	Gage of steel in sidewall	Measurement of Distortion			Leaked after	Remarks
		Drop 2 ft. Length	Drop 4 ft. Length	Drop 6 ft. Length		
1	18	18 in.	22 in.	22¾ in.	No leaks	
2	18	19 in.	18¾ in.	21½ in.	No leaks	
3	18	19 in.	23¼ in.	27 in.	2 ft. drop	Metal fractured at junction with distortion from previous drop.
4	18	20½ in.	24¼ in.	22¾ in.	No leaks	
AVERAGES		19.1 in.	22.1 in.	23.5 in.		
1	19	19¾ in.	25 in.	21 in.	6 ft. drop	Metal fractured at junction with distortion from previous drop.
2	19	19½ in.	23¾ in.	25 in.	6 ft. drop	Metal fractured at junction with distortion from previous drop.
3	19	20½ in.	25 in.	27½ in.	6 ft. drop	Metal fractured at junction with previous drop.
4	19	22 in.	26 in.	....	5 ft. drop	Metal fractured at junction with distortion from previous drop.
AVERAGES		20.44 in.	24.94 in.	24.4 in.		
1	20	21¾ in.	26 in.	26 in.	6 ft. drop	Metal fractured at junction with distortion from previous drop.
2	20	21 in.	25¾ in.	26 in.	6 ft. drop	Metal fractured at junction with distortion from previous drop.
3	20	19 in.	25¼ in.	26¾ in.	6 ft. drop	Metal fractured at junction with distortion from previous drop.
4	20	22¾ in.	26¾ in.	28½ in.	6 ft. drop	Metal fractured at junction with distortion from previous drop.
AVERAGES		21.1 in.	26.0 in.	26.8 in.		
2	20	....	....	26½ in.	No leaks (One 6 ft. drop)	
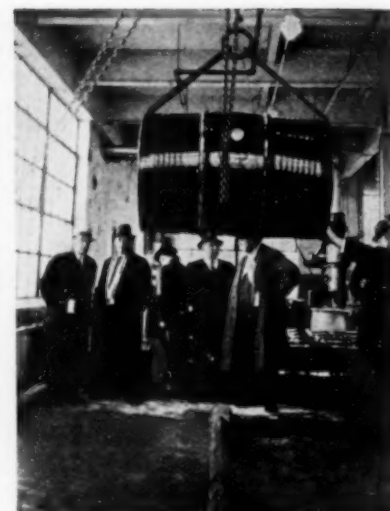
In the impact test the specimen is dropped from 2, 4 and 6-ft. heights onto a 4-in. angle iron on the floor

manufacturers. Drums are designated as numbers 1, 2, 3, and 4 to show the maker. The letters "A", "B", and "C" designate the construction of the drums as follows:

A—Heads painted white—18 gage steel in heads and body.

B—Heads painted yellow—18 gage heads and 19 gage body sheets.

C—Heads painted black—18 gage heads and 20 gage body sheets.

General Specifications for All Types of Drum

Heads crowned to depth of ¾ in.—not over ⅞ in.

Head seams lined with animal glue.

Openings—2 in. in body at center and ¾ in. vent in one head. Flanges are of mechanical type without cap seal, and plugs have 3 threads engaged.

Types 1, 2 and 3 in all constructions—A, B and C had corrugations in the shell—type 4 did not.

Weights and Outage—Each drum resting on its rolling hoops was filled with water to within 1½ in. of the bottom of the spud. This was verified for every drum. The average weight of contents was approximately 460 lb. The average tare weights of the drums were: A—52 lb. B—47 lb. C—42 lb.

Hydrostatic Tests—Water pressure was applied gradually. At the point when the heads bulged to the plane of the chime the pressure was recorded. This point was indicated when the head touched a steel rod placed across the chime of the drum. Pressure was then gradually increased to 36 lb. and maintained for 3 minutes. An accompanying photograph shows results of the test. On the completion of this test the pressure was gradually raised on drums 4A, 4B and 4C until they leaked. This also was recorded.

Drop Tests—Drums were dropped to land diagonally on the chimes on a concrete floor. The first drop was from a height of 4 feet. If no leak resulted the distance of drop was increased to 5 feet and then 6 feet.

Physical Properties of Steel Used in Test Drums
Tensile Tests

Sample		Yield point lb./sq.in.		Ult. strength lb./sq.in.		Elongation % in 2 in.	Rockwell Hardness	Micrometer Thickness	U. S. Std. Gage
1 A	L	37400		50900		24.0	B 55	−.046 in.	.0478 std.
	LL	36900		50900		27.0			
	Avg.	37100		50900		25.0			
2 A	L	32500		46700		27.0	B 53.5	+.0505 in.	.0508 max.
	LL	31700		46700		28.0			.0449 min.
	Avg.	32100		46700		27.5			
3 A	L	28100		47600		34.0	B 48	+.0515 in.	
	LL	30100		47900		33.0			
	Avg.	29100		47700		33.5			
4 A	L	31000		48400		27.0	B 58	+.051 in.	
	LL	33100		49000		26.0	Avg. 28.2		
	Avg.	32000	33425	48700	48500	26.5		53.4	
1 B	L	20600		40800		26.0	B 45	+.043 in.	
	LL	20600		40800		25.0			.0418 std.
	Avg.	20600		40800		25.5			
2 B	L	22900		43100		38.0	B 28	+.046 in.	.0448 max.
	LL	25100		43100		36.0			.0389 min.
	Avg.	24000		43100		37.0			
3 B	L	26000		40800		32.0	B 29	+.0445 in.	
	LL	23000		40800		34.0			
	Avg.	24500		40800		33.0			
4 B	L	29200		46300		27.0	B 56	+.0435 in.	
	LL	30800		45200		29.0	Avg. 30.9		
	Avg.	30000	29500	45700	32600	28.0		39.5	
1 C	L	20100		38300		25.0	B 31	−.035 in.	
	LL	19000		38100		31.0			.0359 std.
	Avg.	19500		38200		28.0			
2 C	L	24200		38400		28.0	B 37	−.034 in.	
	LL	24500		38400		27.0			.0388 max.
	Avg.	24300		38400		27.5			.0344 min.
3 C	L	24100		43500		30.0	B 42.5	+.0385 in.	
	LL	21200		43500		32.0	Avg. 29.0		
	Avg.	22600	23400	43500	41480	31.0		40.2	

As a result of the impact test, specimens *3A*, *3B*, and *3C* were all dropped at 2, 4 and 6-ft heights and leaked only after the last and highest test
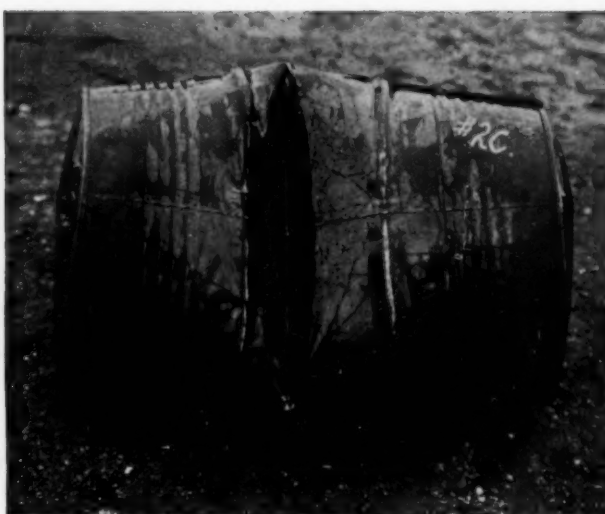
This specimen *2C* was dropped only once from a height of 6 ft. and withstood the test without leakage. It is one of the new light-weight drums

Drums were dropped so as to land on same part of chime each time. The accompanying photograph shows the apparatus used. After each test the deformation was measured as follows and recorded.

Impact Tests—A piece of 4 in. single angle iron was fastened to 3 2 in. x 6 in. planks as shown in the photograph. Drums were dropped flat on their sides until leakage occurred from heights of 2 ft., 4 ft. and 6 ft., successively. The points of impact were between the rolling hoops and away from the openings. After each drop the drums were turned so they did not land twice at the same point. The length and depth of the distortion was measured. The depth measurement is not shown as accurate measurements were not obtainable.

One drum of the 20 gage side wall construction shell was dropped from a height of 6 feet to determine whether one drop from this height would rupture the 20 gage sheet. The angle iron was 9 inches above floor level so the full force of the drop was exerted on the drum.

Nature of Test Samples

Samples measuring 14 in. x 4 in. were cut from the sidewall of each type of drum made by each of the four drum manufacturers. The pieces were cut from drums which had not been tested. The letters represent the gage of steel and the numbers designate the drum manufacturers. Tests were made by J. J. Barclay, the chief metallurgist of the Carnegie Illinois Steel Corp.

The tensile test results show that the samples vary considerably in their physical properties. However, the stress-strain curves indicate that all have received some final cold working such as ungerer levelling or cold rolling. The micrometer thickness of the samples shows that light 20 gage to heavy 18 gage sheets have been used in the tests.

All Are Safe Shippers

Shipping Tests—1. One drum of each construction was shipped from Parlin, N. J., filled with water (450 lb. net) to Cleveland by l.c.l. freight and returned to Parlin. Impaction of these drums disclosed the following:

Drum 2 (18 gage sidewalls)—3 minor dents—hoops and chimes in good condition.

Drum 2 (19 gage sidewalls)—4 minor dents—hoops and chimes in good condition.

Drum 2 (20 gage sidewalls)—7 minor dents—hoops somewhat flattened and chimes slightly dented.

There were no serious defects noted in any of the drums.

2. One drum of each construction was shipped from Linden, N. J., to Chattanooga, Tenn., by l.c.l. freight and returned. Drums were filled with water and calcium chloride was added to prevent freezing. The net weight contained in each drum was 506 lb. Inspection of these drums disclosed the following:

Drum 1—(18 gage sidewalls)—2 minor dents—hoops and chimes in good condition.

Drum 1—(19 gage sidewalls)—4

minor dents—hoops and chimes in good condition.

Drum 1—(20 gage side walls)—8 minor dents—1 major dent—hoops partially flattened—chimes in good condition. It was evident from the marks on this drum that it received a drop more severe than the other two drums encountered, causing a major dent. One lb. of liquid had leaked through the bung of this drum. Careful examination showed that leak was through a faulty gasket.

Shipping tests show that all three types are safe shippers, although the 20-gage sidewall will dent easier and rolling hoops will flatten somewhat with heavy loads.

Correction

In the article entitled "A View of Grinding Fundamentals" by W. L. Maxson which appeared on pages 226-229 of the May, 1938, issue of *Chem. & Met.*, an editorial effort at condensing the original paper led to an ambiguous statement in the section dealing with the rate and effects of wear of the grinding media. The sentence occupying lines 28-34 of the third column on page 229 should read: "In dry grinding the rate of wear is usually considerably lower than in wet grinding and, therefore, the progressive size and shape change of the grinding media is less marked. The progressive change is also less marked in the heterogeneous type as compared with the controlled surface type of mill, primarily because of the greater amount of grinding surface available in the former type."

Gas Absorption in Wet Cyclones

Tests recently conducted by the authors on two commercial-scale dust scrubbers have shown that this equipment may be operated with high efficiency in gas absorption when the proper solvent is employed.

SPRAY CHAMBERS are not generally considered satisfactory as gas absorbers. As is reported below, however, it has been found possible to accomplish good absorption of soluble constituents from dilute gases, using a special type of wet cyclone scrubber or washer in which the proper solvent is circulated. Evidence has been found of further disintegration of the particles of solvent spray, owing to the high velocity of penetration of the gases—an action which greatly increases the absorption surface per unit volume of the scrubber. As a part of the study it has been found possible to develop a theory of absorption by droplets that agrees closely with experimental results and so should be of value for use in other cases, particularly those in which the motion of the droplets can be more easily predicted.—Editor.

V ARIOUS TYPES of spray tower have been suggested for use in gas absorption.[12] Theoretically it would be expected that atomization of the absorbing liquid would provide a large surface of contact, and that such a surface traveling through the gas would be ideal for the absorption of very soluble gases.[10] Measurements made on single droplets of known size have verified this to the extent

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of proving the existence of a high absorption coefficient.[13, 4] In practice, however, simple spray towers have not met with the favor that the theory would apparently justify. Their use is limited to a few industries in which large quantities of solvent can be circulated, and to certain types of humidification and dehumidification equipment. In the chemical industry they have proved poor competitors to packed absorption towers. Even for the treatment of large volumes of gases, for which they would apparently be ideally suited because of their simplicity and low pressure loss, their use has been dismissed as ineffective.[11] Unfortunately, most of these towers have been designed by the "rule of thumb method" without thorough appreciation of the effect on the efficiency of the absorber of such factors as the size of the spray droplets, their interfacial velocity, the number of droplets per unit volume of scrubber, and the mechanism of mass transfer to the liquid surface.

Actual data available on absorption coefficients in spray towers are mostly limited to measurements made in small towers, in which the effect of the wall and of the type of spray nozzle is so great that it is impossible to draw any conclusions as to the exact performance of the spray itself. A few measurements on a large spray

tower of conventional design, which are available to the authors, indicate that the rate of absorption was high immediately in front of the nozzles but that it dropped off rapidly with distance. While the size distribution of the droplets from the nozzle was not known, it is obvious that the smallest particles, which were the source of the major portion of the absorption, lost their initial kinetic energy and could not penetrate more than a few feet into the gas.

The development of the wet cyclone washer[2] for the removal of dust from gases has suggested that the high velocities of the small droplets, resulting from the centrifugal action of the gases, might be conducive to rapid gas absorption. Such a washer consists of a vertical cylindrical shell with a tangential gas inlet at the bottom and a central gas outlet, with straightening vanes, at the top. The water used for removal of dust from the gases is circulated through the washer by means of a centrifugal pump. After leaving the washer, it passes into a settling cone from which the underflow carries the dust collected by the spray particles. Make up water is required in proportion to that lost by evaporation and in the underflow.

Experimental Tests

Desiring to test the possibility of using such a washer for gas absorption when treating large quantities of dilute gases, the authors were fortunate in having an opportunity to study the performance of two units from this standpoint. These washers normally operate for the sole purpose of dust removal. The removal of sulphur dioxide from the gases is

limited by the solubility in the small amount of water wasted from the system. The general program of the test, therefore, at first consisted in adding a solution of sodium carbonate to the circulated water at such a rate as to keep the effluent from the washer definitely on the alkaline side of neutrality. Later the pH was changed to 5.3–6.5. The results indicate the maximum efficiency of the scrubber when absorbing a very soluble gas with no liquid film resistance, since the absorption of sulphur dioxide by alkaline solutions has been shown to be independent of this film.[7] They further indicate that this film does not affect the absorption when the solution is on the acid side but still contains sufficient sulphite ions to produce the partially buffered effect desirable for a cyclic process for absorbing sulphur dioxide,[6] since the results were essentially the same for both cases.

The two washers operated as a single unit on the gases being treated for dust removal. Each washer discharged into its own settling cone and the overflow from these passed to a single pump which sent the solution to the nozzles at 45 lb. per sq. in. Make-up water was added in front of the pump. The washers themselves were 10.3 ft. internal diameter, and 20.0 ft. high. They were lined with acidproof brick to prevent corro-

Interior view of "Right" scrubber after 8 months' operation

sion by the acid water normally circulated. The central manifold in each scrubber was equipped with 80 lava nozzles of the Sturtevant type with 3/16-in. orifices. These nozzles were set so that they led the gases. To prevent interference with the normal operation of the plant during the test, conditions were taken as they were found. For this reason it was not discovered until a few days after the test that eight of the nozzles in one washer and 44 in the other were clogged, a condition resulting from eight months' previous operation. For a similar reason, it was not discovered until later that dust accumulations in the tangential entrance to one washer was slightly more than it was in the other. These entrances are normally 52 in. high and 37 in. wide.

It was observed during the test that the one washer (designated as "Right"), taking the smaller amount of gas with the smaller amount of water, gave slightly lower removal efficiency than the other (designated as "Left"). The difference was attributed to the lack of uniform distribution of the solvent. Since measurements were made only on the total flow to the two scrubbers, a proportioning was made on the basis of the number of nozzles operating and the relative open areas of the gas entrances. It was concluded that the "Right" washer operated on 44 per cent of the gas with one-third of the solvent, or 50 gal. per minute; the "Left" washer operated on 56 per cent of the gas with two-thirds of the solvent, or 100 gal. per minute.

The accompanying illustration is an interior view of the washer designated as "Right," taken after the test. As indicated above, this washer had been in operation for eight months previous to the test without servicing. A s h accumulations were more severe than in the other washer due to the clogging of some of the nozzles. The picture illustrates nicely the spiral action of the gas.

During the test the inlet gas rate to the two scrubbers was varied from 60,000 cu.ft. per min. at 413 deg. F. to 105,000 cu.ft. per min. at 471 deg. F. The quantity of solution in circulation was approximately 38,500 lb. The rate of circulation was maintained constant at 150 gal. per minute. The rate was obtained from a power meter installed on the pump motor and the efficiency curve for the pump. It was inadvisable to insert orifice meters in the lines for the test, owing to the fact that all pipes were rubber lined and permanently installed. Make-up water was added from the city water main through a meter.

The rate of underflow from the settling cones was determined by actual measurement at intervals during the test. In spite of this fact, however, the water balance on the test was not good, there being approximately as much water accounted for in the evaporation alone as was added as make-up. It was planned also to make a sulphur balance, but it was found that this was impossible due to the volume of the solution in the settling cones, which varied in composition from top to bottom and as the test progressed. Unfortunately, this prevented the determination of the percentage of the sulphur dioxide oxidized to sulphate in the absorption. This would be important information from a large scale test. These inadequacies, of course, have no bearing on the real purpose of the test, which was to determine the efficiency of the washer as a gas absorber. This was found directly from gas analyses made as described below.

Gas temperatures were taken at frequent intervals by means of calibrated thermocouples at suitable points across the inlet and outlet ducts of the washer. The temperature of the effluent water from both washers was approximately constant. This was taken as the wet bulb temperature of the gas. The humidity of inlet and outlet gas streams from each washer could then be determined from the actual gas temperatures and from these the efficiency of humidification found. The high temperature humidity chart of Lavine and Sutherland[8] was used in these calculations.

Samples of the overflow from one settling cone were taken every five minutes during the test and the pH and sulphite and bisulphate ion concentration determined immediately. The total sulphur concentration, from which the sulphate ion content was found by difference, was determined later gravimetrically. The pH was determined colorimetrically using standard indicators. Total sulphur dioxide was determined iodimetrically and bisulphite was found by titrating a sample with standard hydroxide after oxidation with neutral hydrogen peroxide. Sulphite was then found from the difference in these values.

Gas analyses were made on the inlet and outlet to each washer during the test. The sampling tubes were ½-in. lead pipes extending to points near the middle of the ducts. Simultaneous samples were drawn from the two positions by means of two small motor-driven vacuum pumps. The gas passed first through bottles of glass wool, then through standard sodium hydroxide containing excess hydrogen peroxide. From this point the blowers discharged through dry gas meters. The titration of the excess hydroxide in each bottle gave the volume of sulphur dioxide, and this, with the corrected volume of inert gas from the gas meters, gave the volume percentage of sulphur dioxide in the gases.

Results

The principal results of the test are shown in Table I, together with the conditions prevailing at each time interval. (The original tabulation shows also the cone underflow and
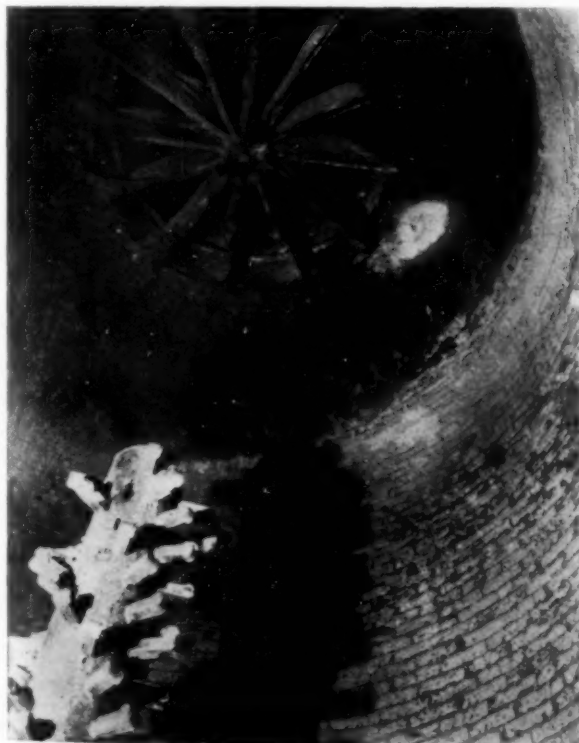
overflow compositions at the various intervals, together with the overflow temperature, underflow pH, and the humidity of the inlet and outlet gas.—Editor.) The volume absorption coefficient, $k_g a$, was calculated from the gas composition, the rate of gas flow, and the assumption that the equilibrium vapor pressure of sulphur dioxide over the solution was zero. The per cent humidification represents the actual change in moisture content compared with the total change if the gases had been reduced to the wet-bulb temperature.

The results show that the percentage removal of sulphur dioxide in the right washer, operating with partially clogged nozzles, was approximately 85 per cent, while that in the left washer, which received nearly twice the volume of solvent, was better than 95 per cent. The absorption coefficients for the two washers are in fact almost in proportion to the quantity of solvent each received, the average being, respectively, 1.58 and 4.05. There is no evidence of a decrease in the absorption coefficient as the pH of the solution entering the washers was decreased from 8.4 to 5.8. Below this value, however, the efficiency of the washers decreased rapidly, evidently due to a finite vapor pressure of sulphur dioxide over the solution as the bisulphite point is approached.

While the data are insufficient to show definitely that the velocity of the gases through the washer is without effect on the absorption coefficient, it is evident that this effect cannot be large as a twofold change in the gas flow decreased it only slightly.

It is interesting to note that the humidification efficiency of the washers agreed closely with the efficiency of sulphur dioxide removal, the actual values running slightly above the absorption percentages. This agrees with the expectation that the evaporation of water through a film of gas proceeds slightly faster than the transfer of sulphur dioxide due to the greater diffusivity of the molecules of water vapor. From a practical standpoint this fact is of importance as it proves that it is impossible to remove sulphur dioxide from a gas by this method without saturating the gas with water vapor simultaneously.

Evidence of the small oxidation of the dissolved sulphur dioxide was shown by an increase in sulphate content of the overflow solution from 0.014 moles per liter to a maximum of 0.053. On the other hand, the total SO₂ increased from 0.0008 to over 0.2 moles per liter.

Table I—Performance of Cyclone Scrubbers as Gas Absorbers in Removing Sulphur Dioxide From Gases by Soda Ash Solution

Time	Gas Rate, Cu.Ft./Min. at 60° F.	Solution, pH	Washer	Temp. Gas, F. In	Out	Per Cent Humidification	SO₂, Per Cent by Volume (dry basis) In	Out	Per Cent Removal	Experimental Coefficients, $K_g A$*, lb. moles/(hr.)(cu. ft.)(atm.)
10:20	45,700	2.8	R†	...	.....	....	0.0555	0.0462	16.8	....
11:05	Na₂CO₃ started									
11:15	45,700	4.0	R	448	162.0	89.1	0.0545	0.0088	83.9	1.84
11:37	45,100	8.4	R	449	162.5	89.5	0.0577	0.0096	83.3	1.74
12:00	46,800	8.3	R	448	164.7	88.9	0.0558	0.0082	85.3	1.96
12:25	46,200	8.1	R	446	161.0	89.8	0.0544	0.0096	82.5	1.76
12:46	45,100	7.9	R	445	162.0	89.5	0.0550	0.0119	78.3	1.54
1:15	44,000	7.4	L‡	444	136.7	98.7	0.0409	0.0023	94.5	3.47
1:40	59,400	7.0	L	468	135.0	99.5	0.0574	0.0019	96.6	5.50
2:00	58,500	6.9	R	475	169.2	88.5	0.0579	0.0135	76.7	1.47
2:30	38,600	6.8	R	460	169.2	88.1	0.0507	0.0117	77.0	1.96
2:58	Na₂CO₃ stopped									
3:23	33,900	5.8	L	405	139.0	99.5	0.0696	0.0027	96.0	2.98
3:43	Na₂CO₃ started									
3:50	33,900	5.5	R	400	155.0	90.1	0.0700	0.0189	73.0	0.99
4:10	33,500	6.4	R	400	155.5	89.7	0.0734	0.0188	74.2	1.00
4:33	32,700	6.4	L	400	140.0	94.5	0.0701	0.00017	99.6	5.15
4:45	Na₂CO₃ stopped									
5:00	33,500	6.4	L	400	140.0	94.5	0.0683	0.0022	96.8	3.11
5:21	33,500	5.6	L	400	140.0	94.5	0.0700	0.0391	44.2	....
5:45	33,500	5.0	L	...	.....	....	0.0672	0.0610	9.23	....
6:05	27,000	4.8	L	...	.....	....	0.0516	0.0603	....	....

* Average: Left Washer = 4.05: Right Washer = 1.58.
† Right Washer operated on 44 per cent of the gas with 50 gal. water per min.
‡ Left Washer operated on 56 per cent of the gas with 100 gal. water per min.

As mentioned above, it is impossible to determine the exact percentage oxidation as the composition of the entire solution was not known.

During the period of the test 17,141,000 cu.ft. of gas (60 deg. F.) was washed, using 121,676 lb. of make-up water to which 1,679 lb. of soda ash was added. It was calculated that 96,715 lb. of water was evaporated and that 1,329 lb. of sulphur dioxide was absorbed. The values for make-up water and water evaporated should be accurate and their difference should correspond to the water lost in the underflow and by spray. Since this difference was small in any case, the loss by spray could not have exceeded a fraction of a per cent of the total water circulated. The quantity of sulphur dioxide absorbed, calculated from the gas analysis, followed the equivalent quantity of soda ash added, the ratio becoming greater than unity when the sulphite ratio of the solution was exceeded, that is, when sodium bisulphite was being formed.

Discussion of Results

In order to be able to apply the results of this test to the design of similar scrubbers for other quantities and compositions of gases, it is quite important to have some working theory of the operation of the scrubber. This requires a knowledge of the size of the droplets, their speed through the gas, and the mechanism of absorption by a spray droplet.

The authors have been fortunate in obtaining some measurements on the size distribution of the droplets leaving the nozzles. These were made by H. G. Houghton, of the Round Hill Research Division, Massachusetts Institute of Technology, who used the methods somewhat improved over those previously described for finding the size and size distribution of fog particles.[5] The measurements were made on a new nozzle of the same type as that used in the test. The pressure on the nozzle was 65 lb. per sq.in. to compensate for the difference in temperature, which was 60 deg. F. The results of these measurements are shown in the first several columns of Table II. They are interesting as they show the extremely large number of particles per unit volume of liquid that can be produced by a simple spray. Similar measurements on another type of lava nozzle produced even greater atomization. It is to be noted that while the number of drops in the small sizes is very large, their fraction of the total volume is small. On the other hand, there is a fairly uniform distribution of area between the sizes of 100 and 800 microns.

Little is known of the velocity of particles in a cyclone washer, particularly of such non-rigid particles as droplets of a liquid which are known to be distorted at high velocities by the resistance of the gas. Calculation of the radial velocities according to the method of Anderson[1], assuming rigid spheres of unity specific gravity, gives velocities for the larger particles that are impossibly high, as has been shown by meteorologists.[6] However, droplets below 200 microns in diameter appear to reach velocities agreeing closely with Stokes' Law. In order to calculate the theoretical volume absorption coefficients given in column (7) of Table II, it was necessary to calculate theoretical radial velocities of the various sizes of droplets, from which the time of contact with the gas could be determined. Recognizing that the Stokes' Law velocities for the larger droplets must be much higher than actual, it is clear that contact times so obtained must be too low, and that the coefficients so calculated are also too

low. The experimentally determined coefficients show this to be the case.

Because of the instability of water droplets traveling at high speeds, it is considered quite probable that further atomization takes place in the scrubber after the particles leave the nozzle. Just what is the limiting velocity for stability cannot be stated, but it is evidently greater than 65 ft. per second[6] as small droplets will be more stable than large ones due to surface tension. Atomization to even 300 microns, however, would greatly increase the number of droplets and decrease the velocity. Both of these factors tend to increase the absorption efficiency.

Theory of Absorption by a Droplet

Having obtained an idea of the approximate size of the droplets and their speed, it is now necessary to consider the mechanism of absorption by a moving spray droplet. Although some accurate measurements[13] are available on the rate of absorption on individual falling drops, the theory for this particular case does not appear to have been presented.

Although deformation of the drop exists at low Reynolds numbers, it is probable that passage through the gas takes place without turbulence even at high velocities.[3] This means that any gas molecule reaching the surface must do so solely by diffusion. A simple explanation of the absorption, which leads to excellent agreement with experimental data, is the assumption that each drop makes contact with a tube of gas represented by the surface described by its periphery in moving through the gas, and of undetermined thickness, x. This thickness will represent the distance that molecules can move by diffusion while the particular layer is in contact with the drop surface. As the velocity of the droplet increases the thickness of this layer will decrease. For high velocities, it will not decrease indefinitely, but will approach a constant value comparable with the molecular mean free path of the gas. This is assuming that the particle is large compared with this mean free path, and that its velocity is small compared with the molecular velocity. It should be noted that the film in question does not correspond to the so-called "stagnant" film which is visualized adjacent to a surface in turbulent flow but merely represents a zone from which the molecules of the absorbed gas are removed due to the concentration gradient. Its thickness can be found by means of the Maxwell-Stefan rate equation and a material balance. Substituting the thickness so found in the first of these equations gives:

$$\frac{dN}{d\theta} = A k_g \sqrt{\frac{P}{p_{BM}}} \,(p_{A1} - p_{A2}) \qquad (1)$$

$$\text{where } k_g = \frac{1}{RT}\sqrt{\frac{bu}{D}} \qquad (2)$$

Here N = moles of gas absorbed; θ = time of contact; A = surface area; k_g = absorption coefficient; P = total pressure; p_{BM} = mean partial pressure of inert gas; p_A = partial pressure of absorbed gas; R = gas constant; T = absolute temperature; b = diffusivity of absorbed gas; u = linear velocity; and D = droplet diameter, all in consistent units.

Surprisingly close experimental confirmation of Equation (1) is found in the work of Whitman, Long and Wang,[13] and of Hatta, Ueda and Baba.[4] This equation was used in calculating the coefficient column of Table I. Similarly, Equation (2) was used in calculating k_g for Table II, while a was determined for each size of droplet in Table II as the value of the expression: (surface area of a given size of droplets entering per second at 100 gal. per min.) $\times$ (travel time of these droplets) $\div$ (scrubber volume). Column (7) of Table II lists the product of these factors, the integrated value of $k_g a$ being 2.540, which is about 60 per cent of that shown experimentally (Table I). Such factors as the probable excessive velocities calculated for the larger droplets, as noted above, and the possibility that there is at least a small increase in the minus 400 micron droplets owing to the disruption of the larger particles, would readily account for the discrepancy.

The most important application of the theory of the action of the wet cyclone is not the exact calculation of the absorption coefficient, but rather to indicate the effect of changing the dimensions of the cyclone on the coefficient. By combining the several fundamental equations it has been shown that the absorption coefficient increases as the size of the cyclone is diminished. For a constant volume, however, a more efficient scrubber is obtained by increasing the radius of curvature and decreasing the height, since the latter is inversely proportional to the square of the radius. It is apparent that an increase in the tangential velocity decreases the absorption coefficient because it shortens the time of contact of each droplet with the gases.

Table II—Distribution of Size of Water Droplets From Nozzles; and Theoretical Absorption Coefficients During Tests

(Sturtevant nozzle No. 2 in lava at 65 lb. per sq. in. and 60 deg. F.)

Diameter of Drops*, Microns	Number of Drops Measured	Number per Cc. of Spray†	Per Cent of Volume	Area per Cc. of Spray, Sq. Cm.	Per Cent of Area	Theoretical Coefficients	
						$K_g A$	Per Cent of Total
25	878	97,250	0.072	1.9	1.48	0.778	30.7
50	460	51,000	0.334	4.0	3.12	0.589	23.2
100	190	21,000	1.11	6.6	5.15	0.341	13.4
150	89	9,850	1.75	6.9	5.38	0.194	7.6
200	53	5,870	2.46	7.4	5.78	0.135	5.3
250	33	3,650	3.00	7.2	5.61	0.094	3.70
300	22	2,440	3.46	6.9	5.38	0.069	2.72
350	16	1,770	3.97	6.8	5.30	0.0532	2.10
400	13	1,440	4.83	7.2	5.61	0.0465	1.83
450	11	1,220	5.84	7.8	6.09	0.0415	1.63
500	10	1,107	7.25	8.7	6.79	0.0400	1.58
550	8	886	7.74	8.4	6.55	0.0335	1.32
600	7	776	8.79	8.8	6.87	0.0312	1.23
650	6	664	9.59	8.8	6.87	0.0275	1.08
700	5	554	9.68	8.5	6.64	0.0238	0.94
750	4	443	9.84	7.8	6.08	0.0198	0.78
800	3	332	8.94	6.7	5.22	0.0153	0.60
850	2	221	7.13	5.0	3.90	0.0105	0.41
900	1	110	4.22	2.8	2.18	0.0054	0.21
950	0	0	0	0	0	0	0.00
1,200	0	0	0	0	0	0	0.00
	1,811	200,583	100.00	128.2	100.00	2.540	100.0

*Each size group includes drops in a range equal to the interval between groups, containing about the nominal size, i.e., the "100" group includes drops from 76-124 microns.
† Number of drops of each size produced by each cc. of spray.

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T.V.A.'s Phosphate Smelting Results

In several past issues, both this year and in 1935 and 1936, Chem. & Met. has carried articles concerned with the construction and operation of the several electric furnaces for phosphate smelting that have been installed by the T.V.A. at Wilson Dam. The present article describes in detail the operating characteristics of one of these furnaces, while a later article is planned to deal with furnace design.

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IN THE PRODUCTION of phosphorus, a mixture of phosphate rock, coke, and silica is smelted in a furnace. Both blast furnaces and electric furnaces have been used commercially. The gases leaving a blast furnace consist essentially of carbon monoxide, phosphorus vapor, and nitrogen, whereas electric furnace gases contain very little nitrogen, but the principle of phosphate reduction is essentially the same in both. The gases from both types of furnaces contain small proportions of other volatile materials. The fundamentals of the thermal production of phosphorus by the blast furnace method have been discussed by Royster and co-authors[1]. Klugh[2] has published material and thermal balances for the electric furnace method, based mostly on theoretical considerations.

During development of the electric furnace process by the chemical engineering department of the T.V.A. at Wilson Dam, Ala., the operating characteristics of the electric furnace were investigated in detail. A general description of the plant and its operation has been given by Curtis and co-authors.[3, 4, 5]

It is the purpose of the present paper to give material and thermal balances for the actual operation of one of the T.V.A. electric furnaces and to show how the efficiency of the furnace was affected by changes in certain of the operating conditions. The conditions that were varied included the electrical power input and the voltage applied to the furnace, the ratio of lime to silica in

the furnace burden, the proportion of coke in the burden, and the nature of phosphatic material used in the furnace burden.

Laboratory investigations of the phosphate reduction reaction have been performed mostly with tricalcium phosphate. Actually, the principal phosphatic ingredient of rock phosphate is not tricalcium phosphate, but fluorapatite, $Ca_{10}F_2(PO_4)_6$. The heat of formation and other thermal data for this compound are lacking, and its reduction has never been studied in detail.

In the electric furnace the over-all reaction in smelting rock phosphate is the reduction of the phosphate to elemental phosphorus, and the reduction of other components of the rock, such as iron oxide, carbonates, sulphates, etc., by the coke used in the charge. The lime of the rock combines with the silica and alumina in the charge to form a slag which is periodically tapped from the furnace. The iron formed in the furnace absorbs phosphorus, yielding a ferrophosphorus carrying about 25 per cent phosphorus and small proportions of silicon and manganese.

The theoretical proportion of coke to be used in the charge may be calculated as that required for reduction of the several reducible compounds present. In practice a little less than the theoretical is used, inasmuch as no substantial increase in

reduction is obtained by using more than about 95 per cent of the coke theoretically required.

The furnace with which these tests were made (T.V.A. electric furnace No. 2) is shown in Fig. 1. It is a cylindrical furnace, having a maximum inside diameter of 15 ft. 4 in. and a maximum depth of approximately 8 ft. 3 in. It is lined with carbon blocks to a depth of $3\frac{1}{2}$ ft. and above this level with refractory brick. The exterior of the shell is water-cooled. The three electrodes are 30 in. in diameter and are located at the corners of an equilateral triangle 5 ft. 9 in. on a side. The electrodes enter the furnace through water-cooled packing glands in the furnace roof. The gases leave the furnace through an off-take as shown in Fig. 1. They are then burned, hydrated in a spray tower, and the acid collected partly from the hydrator and partly in an electrostatic precipitator. The waste gases leaving the precipitator are discharged to a stack.

During the test runs described in this paper, phosphatic materials passing a $2\frac{1}{2}$-in. screen and retained on a 4-mesh screen were used in the furnace. The silica pebble was crushed to pass a 2-in. screen; and the coke breeze was screened to remove pieces larger than $\frac{5}{8}$ in. The rock and silica were mixed in proportion to give the desired mol ratio of lime to silica.

In a specific test, materials of the compositions shown in Table I were used in the furnace charge. The desired mol ratio of lime to silica was

1.31. For rock and silica of the composition shown in Table I, there would be required 0.75 ton of added silica for 3.19 tons of phosphate, the latter weight being the quantity of phosphate carrying 1 ton of P_2O_5.

Based on the chemical composition shown in the table, the quantity of carbon theoretically required for a charge containing 1 ton of P_2O_5 would be 0.422 ton for P_2O_5; 0.020 ton for 0.09 ton of Fe_2O_3; 0.033 ton for 0.05 ton H_2O; 0.011 ton for 0.04 ton CO_2; and 0.009 ton for 0.02 ton SO_3. This totals 0.495 ton C, or 0.597 ton coke (at 82.9 per cent fixed carbon). The quantity of coke actually used was 0.562 ton per ton of P_2O_5, or a deficiency of 6 per cent, making a total charge per ton of P_2O_5 of 3.19 + 0.75 + 0.56 = 4.50 tons.

The composition of the slag is also shown in Table I while that of the metal tapped from the furnace is: P, 23; Mn, 3; Si, 1.5; and Fe, 72.5 per cent (by difference). The temperature of the slag and metal as tapped from the furnace averaged 2,760 deg. F. (1,516 deg. C.) Not all of the ferrophosphorus was actually separated from the slag. Hence in the material balance the combined weight of slag and metal was measured and the weight of ferrophosphorus calculated from the quantity of iron charged to the furnace, correcting for the unreduced iron oxide in the slag. The quantities of slag and metal per ton of P_2O_5 in the charge were respectively 2.84 tons and 0.093 ton.

Gases leaving the furnace were corrosive and frequently exceeded 1.200 deg. F. in temperature. Sampling was difficult due to these condi-tions and to the fact that there was some suspended material in the gas. Gas samples were withdrawn con-tinuously through a stainless steel tube equipped with a cleaning rod passing through a packing gland. It was not found feasible to measure accurately the phosphorus or mois-ture contents of the gas. Bubbling the gas sample through a small quan-tity of water (which shortly became acid and therefore absorbed a negli-gible proportion of the water-soluble CO_2 and H_2S from the sample) served to remove most of the en-trained material and phosphorus, but these could not be determined since an uncertain amount remained in the connecting tubing as a hard glassy material which could not be removed quantitatively. The approximate ra-tio of P_4 to P_2O_5 in the gases was de-termined. One method consisted in the preferential absorption of P_2O_5 on pure silica and of P_4 on copper gauze at 600 deg. C. Another was by absorption in a column in which benzene was refluxed; the P_2O_5 com-bined with the moisture present and was readily separated from the solu-tion of phosphorus in benzene. These tests indicated that the maximum proportion of phosphorus oxidized was 2 per cent, and the figure under normal operation was probably much less than this.

Composition of the volatile portion of the furnace products was deter-mined indirectly. The gases escap-ing from the water scrubber of the sampling apparatus were analyzed and these data used as indicated be-low. The gas analysis on a volume basis averaged: H_2S, 0.3; CO_2, 2.3; CO, 80.3; H_2, 3.1; and N_2, 14.0 per cent (by difference). It contained no oxygen, saturated hydrocarbons or illuminants.

Material Balance

The calculation of the material bal-ance given in Table II is, for the most part, self-evident. The weights and analysis of the charge, slag, ferro-phosphorus, and non-condensed gases are given in Table I or above. An approximation to the composition of the gas issuing from the furnace was made on the assumption that all car-bon charged is converted to CO and CO_2. In the coke charged, the rock charged, and the electrode consumed there were 0.466, 0.012, and 0.010 tons of carbon respectively. This is 0.488/12 or 0.0407 ton atoms of car-bon. Since the dry, phosphorus-free furnace gas contained 2.3 per cent CO_2 and 80.3 per cent CO (volume or mol per cent) and since a mol of each of these gases contains an atom of carbon, there were $100 \times 0.0407/ (2.3 + 80.3)$ or 0.0493 ton mols of gas. The gas contained 14 per cent N_2, so the quantity of N_2 was $0.0493 \times 14.0/100 \times 28$ or 0.193 ton. From this figure the air leakage was cal-culated: $0.193 \times 29/28 \times 100/79 = 0.254$ tons, since air is 79 per cent N_2 by volume. The quantities of H_2S, CO_2, CO, and H_2 were calculated simi-larly. The quantity of water in the furnace gas was calculated from a hydrogen balance. The moisture in the rock and silica, and in the coke, 0.047 and 0.007 ton respectively, contained 0.006 ton of H_2 which, added to the H_2 in the coke, 0.003 ton, made 0.009 ton charged. The previously men-tioned calculation of H_2 in the gas gave 0.003 ton, leaving 0.006 ton for H_2O,
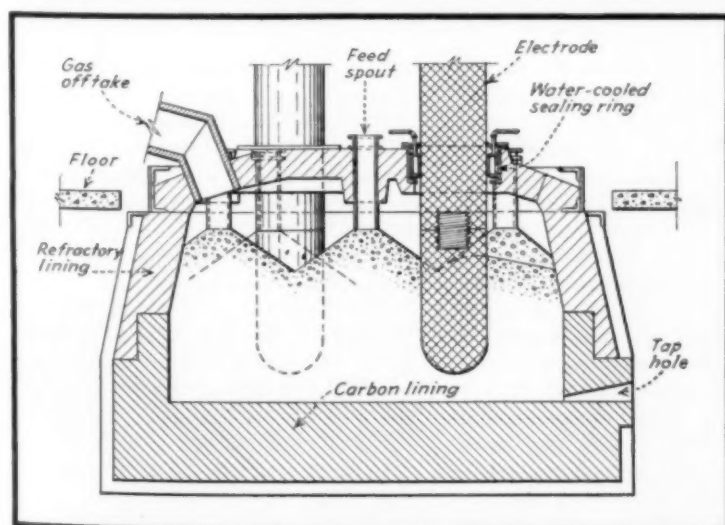
Fig. 1—Schematic cross section of T.V.A. No. 2 electric phosphate furnace

Table I—Composition of Raw Materials and Slag in Per Cent

	Rock	Silica	Rock + Silica	Coke	Slag
H_2O	1.3	0.8	1.2	1.2	0.0
P_2O_5	31.4	....	25.4	....	1.6
CO_2	1.3	....	1.1	....	0.0
Fe_2O_3	2.7	0.6	2.3	2.1	....
MnO_2	0.33	....	0.27	....	....
FeO	....	....	....	....	0.2
MnO	....	....	....	....	0.2
SO_3	0.5	....	0.4	....	....
SiO_2	13.1	97.9	29.2	6.8	41.6
CaO*	44.0	....	35.6	....	49.3
F	3.5	....	2.8	....	2.8
Al_2O_3	0.6	0.7	0.6	3.7	2.5
K_2O	0.18	....	0.15	0.12	0.1
S	....	....	....	1.1†	0.3
C	....	....	....	82.9	....
H_2 (other than H_2O)	....	....	....	0.6	....
Correction for O_2 equivalent to F.	1.5	....	1.2	....	1.2
Other	2.6	0.0	2.2	1.5	2.6
Total	100.0	100.0	100.0	100.0	100.0

* Total calcium as CaO.   † As sulphide.

H₂S, and HF. Since the proportion of hydrogen present as HF and H₂S in the gas was negligible, the amount of water vapor was $0.006 \times 18/2$ or 0.054 ton. Based on the assumption that CO and H₂ are oxidized in preference to phosphorus at temperatures near 1,800 deg. F.,* the oxygen in the air leakage was alloted to the H₂O and CO₂ in order. On this assumption the oxygen in the air leakage, viz., $0.254 \times (21/100) \times (32/29)$ or 0.059 ton (29 being the molecular weight of air) was allocated as follows: for 0.054 ton water, 0.048 ton O₂; and the balance or 0.011 ton to CO₂. The balance of the CO₂ (viz., 0.035 ton, was considered to have been volatilized without reduction. Of course, it could have been considered that all of the CO₂ was reduced and only a portion of the H₂O, but this would make no difference in the ultimate balance. It has been found in most cases that substantially all the CO₂ and H₂O in the charge are reduced by carbon, although they may be later reformed due to oxidation by the air leaking into the furnace.

The quantity of carbon actually used for reduction was then calculated:

For P₂O₅ charged, less P₂O₅ in slag.	(1.000-0.046)	0.403 ton
For Fe₂O₃ reduced to FeO........	(0.006x160/143)	0.0005
For Fe₂O₃ reduced to Fe.........	(0.067x160/111)	0.022
For MnO₂ reduced to MnO.......	(0.005x87/71)	0.0009
For MnO₂ reduced to Mn.........	(0.003x87/55)	0.0013
For SiO₂ reduced to Si	(0.001x60/28)	0.0009
For H₂O reduced	(0.047)	0.031
For CO₂ reduced to CO........	(0.042-0.035)	0.002
For SO₂ reduced to S (as CaS)..	(0.016)	0.010
Total.........................		0.472 ton

The quantity of carbon in the coke and electrode used was 0.476 ton, which is close to the calculated figure, so that the original assumption that all carbon was volatilized was valid.

As a check on these calculations, the quantity of gas passing to the stack (i.e., after burning and removal of acid) was measured by means of a calibrated orifice, the water content was determined by condensation of the water in a measured volume of gas by an ice-cooled condenser, and the CO₂ content of the dry gas was determined by Orsat analysis. The quantity of carbon volatilized from the furnace as calculated from these data was found to agree with the above figure.

It is not certainly known in what form the fluorine, silicon and potassium are volatilized, although SiF₄ and HF have been identified in the gases from the furnace. The combined

Table II—Material Balances
(Tons per Ton of P₂O₅ in Charge)

	Tons	P	Fe	Mn	H	C	S	Ca	Si	Al	K	F	N	O
Phosphate Rock + Silica, 3.945 Tons														
P₂O₅	1.000	0.435												0.565
Fe₂O₃...	0.091		0.063											0.028
MnO₂...	0.011			0.007										0.004
H₂O...	0.047				0.005									0.042
CO₂...	0.042					0.012								0.030
SO₂...	0.016						0.007							0.009
CaO...	1.241							0.886						0.355
SiO₂...	1.152								0.537					0.615
Al₂O₃...	0.024									0.013				0.011
K₂O...	0.0059										0.0049			0.001
CaF₂*...	0.229							0.118				0.111		
Other....	0.086													
	3.945					*Equivalent to F present.*								
Coke, 0.562 Tons														
H₂O...	0.007				0.001									0.006
Fe₂O₃...	0.012		0.008											0.004
K₂O...	0.0007										0.0006			0.0001
SiO₂...	0.038								0.018					0.020
Al₂O₃...	0.021									0.011				0.010
S.......	0.006						0.006							
C.......	0.466					0.466								
H₂.......	0.0034				0.0034									
Other...	0.008													
	0.562													
Electrode, 0.010 Tons														
C.......	0.010					0.010								
Air Leakage, 0.254 Tons														
O₂......	0.059													0.059
N₂......	0.193												0.193	
	0.254													
Total Input.	4.771	0.435	0.071	0.007	0.009	0.488	0.013	1.004	0.555	0.024	0.0055	0.111	0.193	1.759
Slag, 2.840 Tons														
P₂O₅...	0.046	0.020												0.026
FeO...	0.006		0.004											0.002
MnO...	0.005			0.004										0.001
CaO...	1.270							0.907						0.363
SiO₂...	1.180								0.550					0.630
Al₂O₃...	0.071									0.038				0.033
K₂O...	0.003										0.0025			0.005
CaF₂...	0.163							0.083				0.80		
CaS...	0.019						0.008	0.011						
Other....	0.077													
	2.840													
Metal, 0.093 Tons														
P.......	0.021	0.021												
Mn.......	0.003			0.003										
Si.......	0.001								0.001					
Fe......	0.067		0.067											
	0.092													
Gases, 1.841 Tons														
P₄......	0.394	0.394												
CO.....	1.104					0.474								0.630
H₂......	0.003				0.003									
CO₂.....	0.050					0.014								0.036
H₂O.....	0.054				0.006									0.048
H₂S.....	0.005				tr.		0.005							
N₂......	0.193												0.193	
SiF₄ } HF } KF }	0.038								0.004*		0.003*	0.031*		
	1.841					*By difference between amounts charged to furnace and found in slag and metal.*								
Total Output.	4.774	0.435	0.071	0.007	0.009	0.488	0.013	1.001	0.555	0.038	0.0055	0.111	0.193	1.769

quantities of these elements in the gases in Table II were calculated as the difference between that in charge and in the slag and ferrophosphorus.

Several interesting items may be noted about the material balance. Of the phosphorus charged, 4.6 per cent was lost in the slag, and 4.8 per cent went to the ferrophosphorus. While theoretically all of the latter is recoverable, only 60–80 per cent is actually recovered by the means now used. Of the iron compounds charged 92 per cent and 43 per cent of the manganese compounds were reduced and were found in the ferrophosphorus. The percentage reduction of silica was negligible, although the ferrophosphorus

did contain a small proportion of silicon (1.5 per cent).

All of the factors affecting the volatilization of potassium and fluorine are not known. These results, in which 55 per cent of the potassium and 27 per cent of the fluorine was volatilized are typical of results with high-grade lump brown rock phosphate.

The distribution of the gaseous products of the furnace is of some interest. Of the 0.394 ton of phosphorus volatilized, 0.005 ton was recovered in the combustion chamber slag, 0.390 ton was found in the acid, and less than 0.001 ton was found to pass up the stack, indicating a good phosphorus balance. Of the 0.004 ton of

Table III—Thermal Balance

(Basis: 1 Ton of P_2O_5 in Charge)

	Millions of B.t.u.	Per Cent of Input
Input		
1. Electric power 4,970 kw.-hr.[1]	17.0	100
Output		
1. Used in chemical reactions (by difference)	8.1	48
2. Used in heating products		
2.84 tons of slag at 2,760° F. (1,516° C.) = 2.84 x 2,000 x 860[2]	4.9	
0.093 tons of metal at 2,760° F. (1,516° C.) = 0.093 x 2,000 x 540[3]	0.1	
Gases at 1,072° F. (577° C.)		
1.104 tons CO = 1.104 x 2,000 x 262[4]	0.6	
0.394 ton P_4 = 0.394 x 2,000 x 405[5]	0.3	
0.193 ton N_2 = 0.193 x 2,000 x 262[4]	0.1	
0.054 ton H_2O = 0.054 x 2,000 x 1,565[4]	0.2	
CO_2, H_2, H_2S, SiF_4, HF, KF, 0.091 tons, approximately	0.1	
Total	6.3	37
3. Losses		
18,300 lb. electrode cooling water; 19.8° F. temperature rise = 18,300 x 19.8	0.4	
71,200 lb. shell cooling water; 26.8° F. temperature rise = 71,200 x 26.8	1.9	
Radiation and convection[6]	0.3	
Total	2.6	15

[1] Measured at furnace.
[2] Calculated from specific heat of pseudo-wollastonite, Int. Crit. T., Vol. V, page 99.
[3] Calculated from data for iron, Int. Crit. T., Vol. V, page 93.
[4] Calculated from Eastman's equations [10].
[5] Calculated from $C_p/C_v = 1.17$ (C_p assumed independent of temperature). Int. Crit. T., Vol. V, page 80.
[6] Estimated from surface temperatures, using Heilman's data [11].

Table V—Analyses of Phosphatic Materials

(Per Cent Analyses of Materials Used in Runs 16–24)

Run No.	16	17	18	19	20
Moisture	2.2	1.3	0.9	0.5	1.9
P_2O_5	32.8	31.4	30.2	31.2	26.4
CaO	46.8	44.0	43.4	47.3	39.0
SiO_2	7.8	13.1	13.9	9.0	10.9
Fe_2O_3	3.3	2.7	3.4	1.7	7.9
PeO	0	0	0	0	0
Al_2O_3	2.5	0.6	1.0	1.0	1.4
F	3.5	3.5	3.1	3.9	3.3
CO_2	1.6	1.3	2.0	3.9	1.9
S	0.3	0.2	0.1	0.6	5.3
C (Free)	0	0	0	0	0

Run No.	21	22	23	24
Moisture	0.6	0.1	0.1	0.1
P_2O_5	31.4	33.0	24.5	25.6
CaO	45.0	46.4	33.5	36.6
SiO_2	11.4	14.4	24.5	22.8
Fe_2O_3	4.0	3.0	6.0	3.5
PeO	0	0	0	2.5
Al_2O_3	0.8	2.5	9.0	7.8
P	3.5	2.9	2.1	2.7
CO_2	1.5	0	0	0
S	1.2	0	0	0
C (Free)	0	0	0	0.8

silicon calculated to be volatilized, 0.001 ton and 0.002 ton was found in the combustion chamber slag and acid respectively and the balance, 0.001 ton, presumably passed up the stack. No fluorine was found in the combustion chamber slag and only 0.001 ton was found in the acid, so the balance, 0.030 ton, probably went out in the stack gases. Of the 0.003 ton of potassium volatilized, 0.0014 ton was found in the combustion chamber slag, and since it is not likely that potas-

Table IV—Effect of Varying Furnace Operating Conditions and Kind of Phosphatic Material

Run No.	1	2	3	4	5	6	7	8	9	10	11	12	3	13	14	15	16	17	18	19	20	21	22	23	24
	Series I, Power Load					Series II, Voltage			Series III, SiO_2: CaO Ratio					Series IV, Proportion of Coke			Series V, Kind of Phosphatic Material								
																	Plate Brown Rock Rock	Brown Rock Pebble	White Rock	Florida Pebble Rock	Raw Blue Rock	"Burned" Blue Rock	Washed Sand	Nodulized Muck	Sintered Muck
Material Operating Conditions																									
$CaO:SiO_2$ Mol ratio	1.31	1.23	1.26	1.37	1.29	1.27	1.25	1.45	1.10	1.03	0.95	0.89	1.26	1.23	1.23	1.27	1.23	1.27	1.29	1.20	1.23	1.27	1.25	1.20	1.26
Coke, per cent of theory	95	93	96	95	96	96	97	101	101	100	100	105	96	98	99	103	94	95	96	98	103	97	98	97	98
Power load, kw.	4,111	4,537	5,060	5,880	4,650	4,674	4,774	5,150	5,286	5,243	5,300	5,265	5,060	5,490	5,556	5,440	5,550	5,210	5,460	5,550	5,470	5,460	5,540	5,500	5,240
Arc voltage (phase to ground)	108	108	114	121	86	98	121	114	114	114	114	114	114	118	118	122	118	114	118	118	121	118	118	118	118
Current, amperes	15,000	16,500	17,400	19,000	21,200	18,700	15,500																		
Capacity																									
Tons P_2O_5 charged per Day	19.5	21.8	23.5	26.1	20.2	21.5	21.9	23.4	22.5	23.3	22.9	22.4	23.5	25.5	24.8	25.3	24.8	23.5	24.8	23.7	22.8	25.9	27.3	22.6	24.6
Temperatures																									
Slag and metal, deg., F.	2,760	2,800	2,745	2,742	2,795	2,806	2,713	2,701	2,779	2,820	2,782	2,751	2,745	2,860	2,827	2,879	2,827	2,760	2,882	2,800	2,792	2,890	2,935	2,861	2,930
Gases, deg., F.	848	989	1,093	1,287	1,311	1,390	1,246	1,106	1,105	1,009	1,054	960	1,093	998	965	948	965	1,072	917	1,124	1,196	757	637	829	651
Composition of Materials																									
P_2O_5 in rock÷silica, per cent	25.4	25.3	24.9	25.2	25.2	25.5	24.8	26.0	23.6	23.4	22.6	21.8	24.9	25.2	25.2	25.1	25.2	25.4	24.8	23.6	21.7	24.7	26.3	23.7	24.6
P_2O_5 in slag, per cent	2.7	1.4	2.4	2.1	2.4	2.1	1.7	3.2	1.6	1.6	1.0	2.2	2.4	2.0	2.8	2.3	2.0	1.6	2.2	2.6	2.7	2.6	0.5	2.0	0.8
P in metal, per cent	26.0	25.4	25.2	23.8	25.9	26.2	26.8	25.1	24.1	23.6	23.7	23.5	25.2	24.2	26.8	25.5	26.8	23.0	24.3	25.0	25.2	25.2	25.4	25.3	25.5
Energy Requirements																									
Kw.-hr. per ton P_2O_5 charged	4,955	4,910	5,050	5,305	5,430	5,180	5,065	5,195	5,520	5,330	5,380	5,520	5,050	4,845	4,970	4,655	5,320	5,130	5,190	5,530	5,660	5,040	4,850	5,580	5,350
Kw.-hr. per ton P_2O_5 volat's'd.	5,710	5,450	5,790	6,060	6,200	5,570	5,712	6,050	6,303	5,921	5,923	6,369	5,700	5,500	5,680	5,300	6,075	5,665	5,920	6,260	7,570	5,850	5,200	6,960	6,315
Material Balance																									
Input (For detailed rock analysis of Runs 16–24 see Table V.)																									
Rock, tons	3.920	3.900	3.950	3.970	3.920	3.870	3.970	3.940	4.240	4.260	4.430	4.570	3.950	3.945	3.962	3.975	3.050	3.194	3.305	3.198	3.760	3.187	3.028	4.060	3.916
Silica, tons	0.569	0.557	0.561	0.582	0.549	0.593	0.574	0.565	0.604	0.588	0.580	0.589	0.561	0.560	0.567	0.568	0.918	0.751	0.729	1.042	0.824	0.860	0.769	0.128	0.150
Rock + silica, tons	0.020	0.014	0.004	0.011	0.030	0.014	0.014	0.009	0.013	0.009	0.013	0.004	0.004	0.008	0.007	0.008	0.007	0.010	0.034	0.240	0.604	0.047	0.797	0.208	4.066
Coke, tons	0.205	0.146	0.458	0.463	0.273	0.601	0.353	0.358	0.267	0.185	0.284	0.424	0.458	0.254	0.056	0.221	0.058	0.254	0.584	0.564	0.666	0.367	0.538	0.583	0.523
Electrode, tons																				0.004	0.013	0.008	0.007	0.007	0.002
Air leakage, tons																				0.177	0.191	0.064	0.049	0.084	0.093
Total input, tons	4.714	4.617	4.973	5.026	4.742	5.078	4.911	4.772	5.124	5.042	5.307	5.587	4.973	4.767	4.593	4.772	4.601	4.771	4.783	4.985	5.474	4.686	4.391	4.882	4.684
Output																									
Slag, tons	2.750	2.730	2.715	2.905	2.990	2.825	2.850	2.805	3.145	3.170	3.240	3.440	2.715	2.810	2.805	2.910	3.018	2.840	2.941	3.240	3.242	2.930	2.929	3.337	3.000
Metal, tons	0.097	0.105	0.110	0.115	0.083	0.097	0.100	0.099	0.107	0.107	0.109	0.112	0.110	0.098	0.105	0.095	0.105	0.063	0.109	0.059	0.281	0.116	0.088	0.230	0.220
Gases, tons	1.852	1.727	1.990	2.000	1.870	2.130	1.916	1.937	1.876	1.756	1.910	2.010	1.990	1.812	1.605	1.785	1.639	1.840	1.693	1.731	1.689	1.586	1.526	1.496	1.502
Total output, tons	4.709	4.562	4.815	5.080	4.943	5.052	4.866	4.831	5.128	5.033	5.259	5.562	4.815	4.720	4.515	4.790	4.762	4.773	4.743	5.030	5.442	4.632	4.534	5.063	4.722
P_2O_5 Balance																									
Charged, tons	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
In slag, tons	0.077	0.037	0.065	0.061	0.074	0.060	0.050	0.080	0.067	0.043	0.031	0.076	0.065	0.063	0.061	0.067	0.061	0.047	0.064	0.084	0.088	0.077	0.015	0.066	0.024
In metal, tons	0.066	0.064	0.064	0.063	0.050	0.056	0.059	0.051	0.062	0.056	0.062	0.058	0.064	0.055	0.064	0.055	0.064	0.051	0.060	0.034	0.163	0.066	0.051	0.132	0.130
In gases, tons	0.867	0.899	0.871	0.874	0.876	0.884	0.891	0.860	0.871	0.901	0.907	0.966	0.871	0.882	0.875	0.878	0.875	0.902	0.876	0.882	0.749	0.857	0.934	0.902	0.846

sium compounds would be sufficiently volatile to pass out the stack, the balance was presumably in the acid.

Thermal Balance

In previously published heat balances,[1,2] the phosphatic ingredient of rock phosphate has been considered to be tricalcium phosphate. Since the heat of reduction of fluorapatite by carbon is unknown, and since even the reaction products of the volatilization of fluorine are not certainly known, the heat of the chemical reactions occurring in the furnace can be calculated only approximately. The heat in the various portions of the product and that lost in the cooling water and through radiation and convection may be calculated with some degree of assurance, and are given in Table III. These data indicate that the net result of chemical reactions in the electric furnace is endothermic, amounting to about 8.1 million B.t.u. per ton of P_2O_5 in the furnace charge. The figure calculated by Klugh[3] for somewhat different conditions of lime-to-silica ratio and kind of charge was 9.4 million B.t.u. per ton of P_2O_5 charged.

Many tests of the electric furnace were made to determine the best operating conditions and the most economical raw material. Each test lasted from 6 to 14 days, and during a test the operating conditions were held as constant as practicable. The results of 24 of these tests are summarized in Table IV and discussed below.

Effect of Changing Power Load—It is shown in Fig. 2 that the capacity of the furnace increased with increase in load. However, the increase was not linear, indicating that an increase in load above 6,000 kw. would not result in a corresponding increase in capacity and would not be economical, entirely aside from the probable increased deterioration of the furnace lining. The energy requirement per ton of P_2O_5 charged or per ton volatilized (Fig. 3) is seen to increase with increasing load. The air leakage was greater at higher loads since the furnace draft was more difficult to control. Partly because of this increased air leakage, and partly because of the more rapid evolution of gas from the furnace, the gases leaving the furnace were at progressively higher temperatures as the load increased. While this is of little consequence where the gases are burned immediately on leaving the furnace, it is an important factor if the phosphorus is condensed. The temperature and P_2O_5 content of the slag were not affected in a regular manner by changes in load, and it was concluded that they were affected by other variables which could not be controlled closely.

Effect of Changing Voltage—The optimum voltage at which the furnace should be operated has been a matter of considerable concern, since it is known that a high voltage tends to cause local arcing and overheating, resulting in volatization of lime, silica, and the like. In the runs in Series II it was noted that water-white acid was produced at 86 volts, whereas at higher voltages the acid was milky. However, the silica balances were not sufficiently accurate to show any difference in the quantity of silica volatilized, since the quantity of silica recovered in the combustion chamber slag and in the acid was substantially the same in all runs in Series II. It was noted that the capacity increased slightly and that the energy requirement decreased as the voltage was increased. It will be seen that the electrode consumption in Run 5 was the highest of any run. This was caused by the overheating of the electrodes.

Current Density—The results of the runs in Series I and II show the effect of varying the current. The current was calculated from the power and voltage measurements, arbitrarily assuming a power factor of 0.85 in all cases. It may be seen in Fig. 3 that the energy requirement increased with increasing current. Thus from an economic standpoint the current should be as small as possible. High current densities also gave trouble due to overheating the electrodes, whereas this was not true with current densities of less than 28 amp. per sq. in. (19,800 amp).

Effect of Varying Ratio of Lime to Silica—When the ratio of lime to silica was decreased, the P_2O_5 content of the slag decreased and the fraction of P_2O_5 volatilized increased (Fig. 4). Since the quantity of slag increased and the temperature was not greatly affected, more heat was required, so that the electrical energy required increased slightly as shown in Fig. 5. The high P_2O_5 loss in the slag in Run 12 appears to be in error, but may indicate that a maximum volatilization occurs when the lime:silica mol ratio is 1.0. Since good furnace operation was obtained over the entire range of ratio, the proper operating ratio must be determined by an economic balance of the value of P_2O_5 saved versus the increase in cost of silica and electrical energy.

Effect of Changing Proportion of Coke—Since electric furnace operation is extremely sensitive to additions of small quantities of coke through the poke holes in the furnace roof, it was anticipated that the proportion of coke charged could be studied only within a narrow range. It was found under the conditions of the runs in Series III, in which the burden was proportioned and mixed to contain slight excesses or deficiencies of coke, that there was no great change in the P_2O_5 loss in the slag, or in the energy requirements. It might be noted that, in this series, the lower the P_2O_5 content of the slag the higher was the energy requirement. In general, there is a tendency for the slag to be at a higher temperature when more coke is used, but these runs do not illustrate this point perfectly.

A careful analysis of the carbon balances for this series of runs indicated that about 98 per cent of the theoretical proportion of coke was necessary to bring about the actual reduction accomplished and that any slight excess over this amount merely passed out with the slag, without effecting any decrease in the P_2O_5 loss in the slag. Conversely, when less than this amount of coke was used, the carbon lining was attacked, bringing about nearly the same net reduction as if more coke had been used. The operation of the furnace was considerably affected

Figs. 2, 3 and 4—Showing respectively effect of power load on furnace capacity; electrode current on energy requirement; and lime: silica ratio on phosphorus content of slag
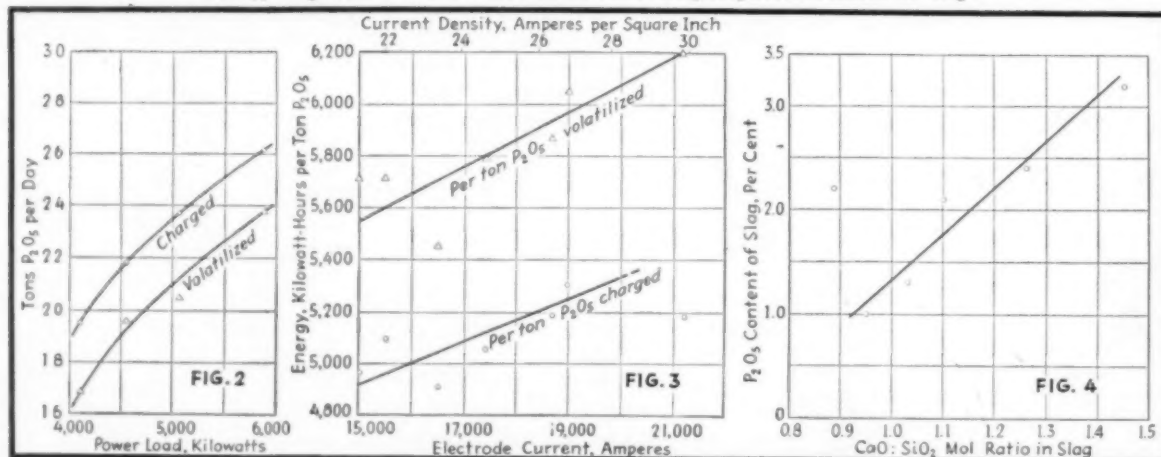
by the presence of excess coke, causing puffing and blowing, and making a dirty gas which is undesirable if the phosphous is to be condensed. When a deficiency of coke was used, the furnace walls tended to overheat and in some cases led to "tap-outs" through the lining and shell.

Heat Losses—The known heat losses did not appear to vary greatly in these tests, and hence are not included in Table IV. It was found that the heat lost in the electrode cooling water increased from about 1 to about 3 per cent of the electrical input, as the electrode current was increased from 15,000 to 21,000 amp. The heat loss through the shell to the cooling water was not affected by changes in load. However, the lower viscosity of the slags of high P_2O_5 content evidently increased the rate of heat transfer to the furnace walls, as will be seen in Fig. 6 where heat loss through the furnace shell is plotted against P_2O_5 in the slag.

Varying Kind of Rock Phosphate

In determining the most economical phosphatic material, not only must the costs of raw materials and electrical energy be considered, but also the smoothness of furnace operation must be included since it affects the production cost in various ways. In Series V of Table IV are summarized the quantitative results of tests using five untreated rock phosphates (four from Tennessee and one from Florida), and four heat-treated rock phosphates. The physical characteristics of these rocks varied considerably and affected the furnace operation. Plate brown rock is relatively soft and was degraded in handling. It tended to arch in the furnace to some extent. The brown rock pebble (Tennessee), being in rounded pieces, was somewhat better in this respect. White rock is hard, may be handled without degradation, but tends to decrepitate on rapid heating. The fine material from the breaking up of the lumps in the furnace tended to seal off the gas passages, causing a puffing, blowing furnace, and making it difficult to control the draft. Pebble rock from Florida is very similar to Tennesse white rock in composition. However, with the pebble the furnace operation was better, probably due to the roundness and uniformity of the particles. Raw blue rock is soft and, because of its low melting point, tended to become sticky and arch in the furnace, causing puffs and preventing a uniform feed. Blue rock was the worst material used from the standpoint of smooth, uniform furnace operation. However, when blue rock is "burned" (piled between alternate layers of wood which are then burned, so that the moisture and a large part of the sulphur are driven off), it becomes hard so that little breaking up occurs on handling, and excellent furnace operation was obtained with the so-called "burned" blue rock.

Washed phosphatic sand, nodulized in a rotary kiln[5] at about 2,550 deg. F., is almost free from dust, and, although the pieces are porous and appear somewhat weak, excellent furnace operation was obtained. Phosphate muck nodulized at about 2,100 deg. F. is similar in physical appearance to nodulized sand, and very good furnace operation was obtained. Sintered phosphate muck contains a considerable amount of dust due to handling

and was rescreened before it was sent to the furnace. In spite of this, the fines caused some difficulty in furnace operation. The sinter contained some unburned coke distributed non-uniformly, which caused difficulty in proportioning the charges and caused irregular furnace operation.

The ease with which the furnace draft may be controlled (and hence the smoothness of gas evolution) may be measured somewhat by the temperature of the gases leaving the furnace. It will be noted that nodulized sand gave the lowest temperature with the other heat-treated rocks closely following. Raw blue rock gave the highest temperature, indicating very unsteady operation.

The furnace off-gas temperatures for the runs of the first 15 tests and Run 19 are not directly comparable with those for the other runs, since the water-cooling seal rings were not in place around the electrodes.

Energy Requirements—Since, as shown in Table V, the proportion of impurities in the rocks (Fe compounds, F, CO_2, S, K_2O, and moisture) varied, the amount of energy absorbed in minor side reactions differed from run to run. The electrical energy requirement was found to decrease as the P_2O_5 content of the rock plus silica increased, as shown in Fig. 7. The capacity of the furnace was found to increase as the grade of burden increased.

P_2O_5 Distribution—Except for one run, the proportion of coke was substantially constant. In the case of Run 20, coke was allowed for the reduction of iron compounds, calculated as Fe_2O_3. Since the iron in blue rock phosphate is probably present as an iron sulphide (FeS_2?) which is decomposed to iron and sulphur in the furnace, probably no coke was required by the reaction, the differences in P_2O_5 distribution may be attributed therefore to differences in the phosphates themselves. The high slag temperature in Runs 22 and 24 is evidence of the presence of excess coke, which is further shown by the low P_2O_5 content of the slags. Apparently, with these materials, the minor reduction reactions did not take place to as great an extent as with the other rocks, leaving a greater proportion

of the coke available for reduction of phosphate. It has been observed repeatedly that sintered rock produced a lower P_2O_5 slag than nodulized muck of the same P_2O_5 content. This is apparently due to a partial reduction of the components of the muck by coke during the sintering process. Aside from these two runs the P_2O_5 loss in the slag was about the same in all runs.

The P_2O_5 loss in the metal was directly proportional to the iron content of the charge. From 86 to 96 per cent of the iron charged was converted to ferrophosphorus. As pointed out in a previous paper[8] this phosphorus is actually more valuable than that converted to acid.

As stated in the first part of this paper, the quantity and gross composition of the gases leaving the furnace were obtained indirectly. Therefore, agreement of the calculated total output with the total actual input constitutes an excellent check on both accuracy of the data and on the assumptions made. For the 24 runs reported, there was an average material gain of 0.012 ton per ton of P_2O_5 charged or about 0.2 per cent, which is considered an excellent check.

The author wishes to acknowledge the help of Drs. H. A. Curtis and R. L. Copson, and other members of the chemical engineering staff, in obtaining the data presented and in preparing this paper.

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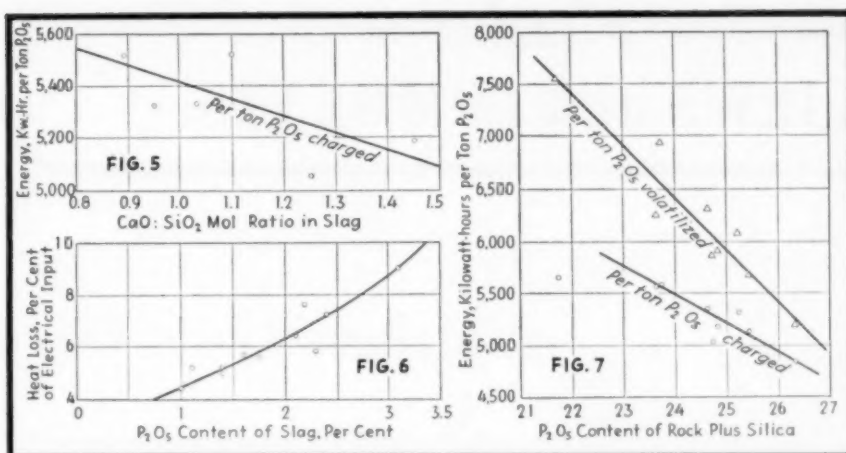
Fig. 5, 6 and 7—Showing respectively effect of lime: silica ratio on energy requirement; relationship of furnace shell heat losses to phosphorus in slag; and effect of phosphorus content of burden on energy requirement

Readers' VIEWS and COMMENTS

Catalysis Costs Discussion

LAST MONTH in its article by Dr. H. W. Mahr on "Catalysis Costs" Chem. & Met. unintentionally omitted acknowledgment to the American Institute of Chemical Engineers for permission to use Dr. Mahr's original paper. This paper was presented at the White Sulphur Springs meeting of the Institute in May under the title "Economic Life and Catalysis Costs of Contact Catalysts." It is discussed here briefly by Andrew M. Fairlie, Atlanta chemical engineer, who has long been prominent in the sulphuric acid field. —Editor.

THE PAPER by Hermann W. Mahr on Catalysis Costs," read before the American Institute of Chemical Engineers at the May meeting and published in the June issue of *Chem. & Met.*, presents the results of a careful analysis of the costs of catalysts, with separation of the aggregate costs into the component parts—initial cost, cumulative operating losses and investment cost—and with illustrations, in the abstract, of methods for the practical application of analyzed costs. The paper is very enlightening, and by means of the methods of application suggested it is possible to evaluate competing catalysts more accurately; to arrive at a fairer

comparison between a non-catalytic and a catalytic process; to calculate how long a deteriorating catalyst should be continued in use; and to determine whether a reduction in daily output of product for the sake of halting or diminishing the loss of catalyst activity is or is not profitable.

Of course, in this brief paper not all of the possible conditions could be considered. For example, it is assumed in the paper that the rate of catalyst depreciation will be constant, per unit of product, over a protracted period. Obviously, the depreciation-rate may vary, owing to changes in the composition of the raw material supplied, to accident, or to other causes. Where changes affecting the depreciation rate are unpredictable, it would be impossible to calculate accurately the life of a catalyst.

In the "Comparison of Catalysts" given in the article, except for the fact that investment costs are assumed to be absent the catalysts compared might have been assumed to be vanadium and platinum for the manufacture of sulphuric acid. In such a concrete case, the handicap of vanadium mass in being unable to cope with gas containing more

than 8 per cent SO_2 could be overcome by passing through the converter 25 per cent more of the 8 per cent gas per unit of time, thereby bringing the product per day up to parity with that from the platinum catalyst, which can handle gas containing 10 per cent SO_2 economically and with safety. However, to move through the plant an additional 25 per cent of raw material (SO_2 and gas) involves a higher cost for power, besides higher costs for installation and maintenance costs for larger flues, converters and towers. The handicap of lower production efficiency can be made to disappear, but there is substituted the handicap of higher fixed charges and power costs.

Without meaning to detract one whit from the value of Dr. Mahr's paper, it may be said that the subject is capable of considerable further expansion, and that a supplementary paper, illustrated by concrete examples of catalysts and processes specified by name, would be helpful in the further clarification of methods for the accurate comparison of catalyst costs.

ANDREW M. FAIRLIE
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RECENT BOOKS AND PAMPHLETS

A Raw Commodity Revolution, by Melvin T. Copeland. Business Research Study No. 19, Graduate School of Business Administration, Harvard University, Boston, Mass. 100 pages. $1.25. A world-wide revolution in many of the raw commodity industries for the last 20 years has resulted in demoralization of prices, financial derangement, social distress, and political unrest. This is the conclusion reached by Professor Copeland after pointing out that advances in technology, together with the development of new sources of production, have resulted in increased productive capacities for many basic commodities and have brought a perennial glut in the markets. The survey includes data on 19 raw commodities important in international trade.

Decolorization of Southern Illinois Silica, by J. S. Machin and F. V. Tooley. Report of Investigations No. 47, State Geological Survey, Urbana, Ill. 35 pages. Discusses decolorization by iron removal, bleaching without removing iron, and factors to be considered in choice of method used. Includes bibliography of 45 references.

A. S. T. M. Symposium on Plastics. American Society for Testing Materials, Philadelphia, Pa. 75 cents. Six papers on thermal properties, flow relations, hardness and permanence of plastics, presented at Rochester Regional Meeting, March 9, 1938.

Federal Tax Law With Explanatory Digest, Revenue Act of 1938. Prentice-Hall Inc., 70 Fifth Ave., New York City. 166 pages. $1. Compiled by Robert Ash. Gives complete statement of Revenue Act of 1938 which covers income tax, personal holding companies, estate and gift taxes, capital stock and excess profits taxes, excise taxes, and miscellaneous and general provisions. Also gives estate tax provisions from Revenue Act of 1926 and gift tax provisions from Revenue Act of 1932, together with amendments to date. A well written and understandable 49-page explanatory digest accompanies the statement of the law.

Report of the Water Pollution Research Board (British), Year Ended June 30, 1937. His majesty's Stationery Office, London, England. 45 pages.

Available from British Library of Information, 270 Madison Ave., New York City. 30 cents. Reports of research on treatment of industrial effluents, sewage disposal, and other phases of water pollution prevention.

Ferro Technical Bulletin. Ferro Enamel Corp., Cleveland, Ohio. A new quarterly technical publication describing research work on enamel coatings carried out at the Ferro Laboratories. Bulletin No. 1, "Heat Transfer of Porcelain Enamel Metals and Other Materials," contains 28 pages and is in the form of a complete research report. No advertising is included. Bulletin No. 2 will appear this month and will be on the subject of "Stabilization of Reflectance and Color in Recoat Porcelain Enamel."

Effect of City Water and Sewerage Facilities on Industrial Markets, by O. C. Holleran. Market Research Series No. 17, U. S. Department of Commerce, Bureau of Foreign and Domestic Commerce, Washington, D. C. With water as one of chemical industry's chief raw materials this survey of available water supply in U. S. cities having a population of 20,000 or more will be of value in plant location studies.

Chemical Engineer's BOOKSHELF

Higher Organic Chemistry

ORGANIC CHEMISTRY. Vols. 1 and II. Edited by *Henry Gilman*. Published by John Wiley and Sons, Inc., New York City. 1,890 pages. Price, $7.50 each volume.

Reviewed by *R. L. Taylor*

UNTIL LAST YEAR when Dean Frank C. Whitmore published his "Organic Chemistry" there was no advanced work on this subject available in English. Now, Dr. Gilman and his 27 distinguished contributing and consulting editors, of whom Dean Whitmore is one, bring forth a second outstanding piece of work which complements the Whitmore book in such a way that together they do an excellent job of covering both the practical and theoretical aspects of modern progress in advanced organic chemistry.

The Gilman volumes stress reaction mechanisms over individual reactions. In general, the contributing authors have not attempted to include all the pertinent descriptive material on possible reactions and products, but they have made certain in practically every chapter to provide sound theoretical basis for proper appreciation of the chemistry involved. This is one of the respects in which the Gilman and Whitmore books differ. The former is inclined to stress the "why" and the latter the "what." There is also a difference in relative amount of space devoted to various classes of compounds. Gilman devotes considerable space to the alicyclic, heterocyclic and complex aliphatic compounds, while Whitmore covers more of the reactions of the simpler aliphatics.

An indication of the scope of the Gilman volumes can be obtained from the following list of chapter headings: Vol. I—alicyclic compounds and the theory of strain; theory of the structure and reactions of aromatic compounds; stereoisomerism; organometallic compounds; free radicals; unsaturation and conjugation; open-chain nitrogen compounds; molecular rearrangements; comparison of chemical reactivity. Vol. II—natural amino acids; pyrimidines, purines, and nucleic acids; alkaloids; anthocyanins and flavones; carotenoids; sterols and bile acids; carbohydrates;

electronic concepts of valence; rotary dispersion; resonance.

An effective job of editing has been done in tying together and cross referencing the various contributions. Literature references have been conveniently standardized and inserted as footnotes. According to the editor both volumes will be revised at intervals to bring the material up to date and add new chapters to fill some of the more conspicuous gaps.

The authors and particularly the editor of these volumes are to be commended on an excellent piece of work which will be invaluable to the research organic chemist and the advanced student.

HISTORY OF GAS

HISTORY OF THE GAS INDUSTRY. By *Louis Stotz* and *Alexander Jamison*. Published by American Gas Association, 420 Lexington Ave., New York City. 534 pages. Price, $3.50 for single copies; ten or more $3 each.

Reviewed by *R. S. McBride*

EVERY GAS MAN will read with much interest this review of the American gas industry. The style of presentation will inspire the industry's readers to greater enthusiasm for their own business, and technical readers outside the industry with a great deal of respect for the way in which gas men have developed their enterprise.

The volume is not a serious presentation of a lot of dry facts in the conventional historical manner, but there is an amazing amount of information and dependable data furnished in an easy, readable style. Perhaps the most serious criticism is the lack of an index. If and when a second edition is prepared, an adequate index certainly should be added so that reference value may be added to the readability of the work.

Chemical engineers will also hope that a later edition will contain numerous additions to those chapters which deal with methods of manufacture and the technology of gas storage and handling. Far greater emphasis on the public utility and public relations aspects of the industry has been given than to these engineering features. This does not militate against the value of the

work for members of the industry or for others interested in utility questions, but it does stop a bit short of the hoped-for goal from the standpoint of chemical engineers.

SOYBEAN PROCESSING

THE SOYBEAN INDUSTRY. By *A. A. Horvath*. Published by the Chemical Publishing Co. of New York, Inc., New York City. 221 pages. Price, $4.

Reviewed by *R. L. Taylor*

THE RECENT RISE of the soybean to a place of industrial and gastronomical importance in this country has been accompanied by much technical information scattered throughout the periodical literature. In his new book Dr. Horvath brings together for the first time the more significant of this material and combines it with his own first-hand experience to produce a brief but well done and highly readable account of soybean processing methods and of the properties and industrial uses of soybean products.

Pressure oil milling versus solvent extraction is discussed, and the advantages and disadvantages of each are considered. The various oil extraction processes are described in considerable detail. In the case of the Ford solvent extraction process, however, the description given is at least two years out of date with respect to kind of solvent used, solvent recovery system and several other details, all of which have been described in the technical literature.

The properties, refining methods and industrial uses of soybean oil are well covered, as are also the uses and methods of extraction of soybean phosphatides and proteins. The subjects of growing of soybeans and their use as food have not been included.

CONVERSION FORMULAS. By *Leland W. Sprinkle*. Published by P. Blakiston's Sons & Co., Inc., Philadelphia, Pa. 122 pages. Price, $1.25.

INTENDED for use by anyone who must convert a quantity from one type of unit to another, this convenient hand-

book contains all common units from Angstroms to light years, teaspoons to tons, and seconds to centuries. It is self-indexing and requires only one operation—multiplication. Typical example: *light years* multiplied by 5,879,810,000,000 = *miles*.

BITUMENS IN INDUSTRY

ASPHALTS AND ALLIED SUBSTANCES. Fourth Edition. By *Herbert Abraham.* Published by D. Van Nostrand Co., Inc., New York City. 491 pages. Price, $12.50.

Reviewed by *J. R. M. Klotz*

THIS is truly a remarkable volume and will be of value to anyone interested in asphalt or any of the allied fields. The historical data included is as good reading as one will find in the rarely good novels. The continuity is so much better than the usual historical hodge-podge that this section is recommended as a model to budding authors.

The book is divided into six parts as follows: general considerations; semi-solid and solid bitumens and pyrobitumens; tars and pitches; pyrogenous asphalts and waxes; manufactured products and their uses; and test methods.

The section on methods of testing is remarkably close to being up to date, and the section referring to patents and general literature and bibliography is also remarkably complete considering the stream of patents being issued almost daily in the field. The method of classifying references by chapters and the combination of the reference number and page number add to the facility of the volume as a reference work.

MATHEMATICS IN A NUT SHELL

ESSENTIALS OF ENGINEERING MATHEMATICS. By *J. P. Ballantine.* Published by Prentice-Hall, Inc., New York, N. Y. 578 pages. Price, $3.75.

Reviewed by *M. E. Clark*

THE TITLE of this work is well chosen, for it indicates exactly what is included between the covers. The author assumes only a meager knowledge of high school algebra with perhaps a touch of plane geometry. In light of that fact he takes the reader right into his private office, locks the door, and sits down in an easy chair, to tell in simple concise statements just what mathematics is made of—why it really isn't complicated at all. He starts out by defining graduations on a line and winds up by showing how to solve a triple integral. The only strange thing about that, of course, is the fact that he requires only 495 pages to do it.

However, the explanations are all so clear, so logical and so informal, thus leaving out a mass of heavy and uninteresting reading, that this is an ideal book for the person who has not had the opportunity to take calculus in school or for the young man who wants to educate himself.

GOVERNMENT PUBLICATIONS

Documents are available at prices indicated from superintendent of Documents, Government Printing Office, Washington, D. C. Send cash or money order: stamps and personal checks not accepted. When no price is indicated pamphlet is free and should be ordered from bureau responsible for its issue.

Acetic Acid Data. Tariff Commission mimeographed release, June 4, 1938.

Synthetic Organic Chemicals, 1937. Mimeographed preliminary statement of production and sales of coal-tar crudes, dyes, and other synthetics. U. S. Tariff Commission release, June 2, 1938. Printed document will appear later giving these and supplementary data.

Current Trends in Imports. Tariff Commission mimeographed statistical summary, June 21, 1938.

Dominion and Colonial Statistics. Tables of data relating to the British Dominions. Tariff Commission Report No. 127, Second Series; 10 cents.

Trade Agreement Between the United States and the Czechoslovak Republic. U. S. Tariff Commission unnumbered processed document.

Federal Power Commission Rules of Practice and Regulations, Effective June 1, 1938. Federal Power Commission unnumbered document; 15 cents.

Marking of Articles Made Wholly or in Part of Platinum. Bureau of Standards Commercial Standard CS66-38; 5 cents.

Heat Transfer Measurements in Connection with Thermal Insulation of Low-Cost Housing. Bureau of Standards Letter Circular LC-502J; mimeographed.

Wintering Beef Cows on the Range with and Without a Supplement of Cottonseed Cake, by W. H. Black, J. R. Quesenberry, and A. L. Baker. Department of Agriculture, Technical Bulletin 603; 5 cents.

A Weather-Resistant Fireproofing Treatment for Cotton Fabrics, by Martin Leatherman. Department of Agriculture, Circular 466; 5 cents.

The Gypsy and Brown-Tail Moths and Their Control, by A. F. Burgess, and W. L. Baker. Department of Agriculture, Circular 464; 10 cents.

Bibliography of Land Utilization, 1918-36. Department of Agriculture, Miscellaneous Publication 284; $1.50.

Pulping and Papermaking Properties of Seed Flax Straw, by Earl R. Schafer and C. E. Curran. Prepared by Forest Products Laboratory, Madison, Wis. Available from Forest Service, Department of Agriculture.

List of proprietary detergents, wetting agents, and emulsifying agents (for use with insecticides), by H. L. Cupples. Available from Entomology and Plant Quarantine Bureau, Department of Agriculture E 426; processed.

Relation of Growth Characteristics of Southern Pine to Its Use in Pulping, by C. E. Curran. Prepared by Forest Products Laboratory, Madison, Wis.; processed.

1936-37 Annual Naval Stores Report. Bureau of Chemistry and Soils, Department of Agriculture; processed.

Alunite Deposits of the Marysvale Region, Utah, by Eugene Callaghan. Geological Survey, Bulletin 886-D; 15 cents.

Injury Experience in 30 Manufacturing Industries, 1935 and 1936, by Roy F. Fleming and Jacob Lotven. Bureau of Labor Statistics, Serial No. R-685; printed.

Lead Poisoning in 1936 and Earlier Years, by Frederick L. Hoffman. Bureau of Labor Statistics, Serial No. R-669; printed.

Biennial Census of Manufactures 1935. Bureau of the Census; $1.75 Buckram.

Auto-Ignition and Combustion of Diesel Fuel in a Constant-Volume Bomb, by Robert F. Shelden. National Advisory Committee for Aeronautics, Technical Report 617; 10 cents.

List of American Doctoral Dissertations Printed in 1936. Library of Congress unnumbered document; 55 cents.

Bleaching - Material (Chlorinating Agents). Federal Specification O-B-441a; 5 cents.

White-lead; Basic Sulphate, Dry and Paste-in-Oil. Federal Specification TT-W-261a; 5 cents.

Market Research Sources. 1938 Edition. Bureau of Foreign and Domestic Commerce, Domestic Commerce Series No. 55; 30 cents.

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The Pollution Problem in the Ohio River Drainage Basin, by H. R. Crohurst. Public Health Service, Reprint No. 1903; 5 cents.

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List of Available Publications of the U. S. Department of Agriculture, January, 1938, compiled by Fred L. Zimmerman and Phyllis R. Read. Department of Agriculture, Miscellaneous Publication 60.

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Directory of Organization and Field Activities of the Department of Agriculture, compiled by Edmund Stephens. Department of Agriculture, Miscellaneous Publication No. 304; 20 cents.

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Construction Activity in the United States, 1915-37. Bureau of Foreign and Domestic Commerce, Domestic Commerce Series No. 99; 15 cents.

Your Plant
NOTEBOOK

A CONVENIENT INTERPOLATION SCHEDULE FACILITATES CHEMICAL ENGINEERING CALCULATIONS

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IF THERE IS one kind of calculation which the chemical engineer performs more frequently than any other, it is interpolation. Interpolations vary from the simple visual variety made so often on the scales of a slide rule, nomograph, or other plot to the more involved types requiring the determination and solution of an empirical equation and computation by the La Grange formula.

Visual interpolation needs no comment despite the fact that individuals do not always agree on so simple a matter as setting the indicator glass of a slide rule to read 2.13. Interpolation of values where there are small tabular differences are usually made by proportion as in determining the logarithm of 29.92 from the recorded logarithms of 29.9 and 30.0. Where the tabular differences are larger and are changing rapidly, interpolation is usually effected by means of plotting the data and reading the desired value from the curve. This latter method is not always sufficiently accurate since it depends upon the construction of a curve, either free-hand or with the use of a mechanical aid. Free-hand curves are necessarily too wide for precision work and in using a mechanical aid one is too prone to follow the line of least resistance along the French curve instead of considering the nature of the data.

Greater accuracy results from fitting an empirical equation to the data but this usually requires some little time and is occasionally quite difficult. When a number of interpolated values is required this method is well worth while although it is usually not practicable when only one or two interpolations are needed. In such instances one turns to the La Grange formula,

$$y = y_1 \frac{(x-a_2)\ (x-a_3)\ \dots\ (x-a_n)}{(a_1-a_2)\ (a_1-a_3)\ \dots\ (a_1-a_n)}$$
$$+ y_2 \frac{(x-a_1)\ (x-a_3)\ \dots\ (x-a_n)}{(a_2-a_1)\ (a_2-a_3)\ \dots\ (a_2-a_n)}$$
$$+ \dots$$
$$+ y_n \frac{(x-a_1)\ (x-a_2)\ \dots\ (x-a_{n-1})}{(a_n-a_1)\ (a_n-a_2)\ \dots\ (a_n-a_{n-1})}$$

where y is the interpolated value corresponding to x and y_1, y_2, y_3, and y_n are the values of the function being interpolated corresponding to values of a_1, a_2, a_3, and a_n.

The La Grange formula appears a bit awesome at first but is really very simple, its main difficulty lying in writing down the numerous confusing subtractions. It is the purpose of this paper to propose a convenient tabular method of handling the La Grange formula and to compare interpolated values effected by the various methods, using well known chemical engineering data.

In the schedule presented in Fig. 1 value of y are tabulated vertically while values of a are tabulated both horizontally and vertically, a diagonal is drawn and the blocks are filled in as follows: The numerator unit consists of the differences between x and the values of a, i.e., $x-a_1$, $x-a_2$, etc. while the denominator unit is composed of the differences between the values of a in the column and those in the top row, that is, they are column-minus-row differences:

Columns headed $+$ and $-$ are found at the right. These are filled in by multiplying the various values of y by the numbers found in the numerator unit blocks and dividing by the numbers found in the denominator unit blocks. Where the total number of negative signs in a single line of numerator and denominator unit blocks is odd the result is negative and is placed in the $-$ column. When the total number of negative signs is even the result is positive and is placed in the $+$ column. The algebraic sum of the results so obtained is the interpolated value, y.

Both the numerator and denominator units exhibit a sort of symmetry so that in each, once the first few numbers are written in, the remainder can be determined rapidly by inspection. The accompanying example will serve to illustrate: Given the following data on the compressibility factors, f, (Bartlett, Hetherington, Kvalnes, and Tremearne, *J. Am. Chem. Soc.*, 52, 1930, p. 1363) of a 3:1 mixture of hydrogen and nitrogen at -25 deg. C., at various pressures, P, to find the value of f at $P = 400$

f	P	f'	P'
0.9609	100	-399	1
1.0264	200	264	2
1.1024	300	1024	3
?	400	?	4
1.2679	500	2679	5
1.3561	600	3561	6
1.5280	800	5280	8

For convenience f is replaced by $f' = 10,000(f-1)$ and P is replaced by $P' = P/100$. It is usually sufficient to

Fig. 1, Top—General schedule for easy visual solution of the La Grange formula
Fig. 2, Bottom—Solution of example where f is compressibility and P, pressure

Numerator Unit

	a_1	a_2	a_3	a_4
y_1		$x-a_2$	$x-a_3$	$x-a_4$
y_2	$x-a_1$		$x-a_3$	$x-a_4$
y_3	$x-a_1$	$x-a_2$		$x-a_4$
y_4	$x-a_1$	$x-a_2$	$x-a_3$	

Denominator Unit

	a_1	a_2	a_3	a_4	$+$	$-$
a_1		a_1-a_2	a_1-a_3	a_1-a_4		
a_2	a_2-a_1		a_2-a_3	a_2-a_4		
a_3	a_3-a_1	a_3-a_2		a_3-a_4		
a_4	a_4-a_1	a_4-a_2	a_4-a_3			

f'	2	3	5	6
264		1	-1	-2
1,024	2		-1	-2
2,679	2	1		-2
3,561	2	1	-1	

P'	2	3	5	6	$+$	$-$
2		-1	-3	-4		44.0
3	1		-2	-3	682.7	
5	3	2		-1	1,786.0	
6	4	3	1			593.5
					2,468.7	637.5

2,468.7 − 637.5 = 1,831.2

Process Equipment NEWS

Machinery, Materials and Products

Welded Portal Truss

A NEW fertilizer plant for International Agricultural Corp., first industrial structure utilizing the new welded portal truss designed by engineers of The Austin Co., Cleveland, Ohio, to accommodate conveyors on rails passing through the roof members, is nearing completion at Chicago Heights, Ill.

The unusual trusses, which are a functional part of this all-welded rigid-frame structure, were completely prefabricated in the Austin shops at Cleveland. They provide twelve 7-ft. passageways just below the building's roof and rails extending between the trusses will carry industrial cars, which in turn will be loaded from elevator towers overhead. Special rail supports, as well as all the other structural members, were welded in the 'leveland fabricating shop. A total of 250 tons of structural steel was used on the job, which required 13,000 lineal ft. of welding, only 1,100 ft. of which was welded in the field.

The design would appear to lend itself to many other uses, since the portal trusses will accommodate monorails directly on their bottom chords and provide conveyorways or walkways through the portals, as well.

Portable Hardness Tester

WEIGHING ONLY 6½ lb., the new Telebrineller recently put on the market by Teleweld, Inc., Railway Exchange Bldg., Chicago, Ill., is intended for making hardness tests in the field, in close quarters and under other adverse conditions. Among the suggested uses is the testing of parent metal adjacent to welded joints in alloy steel pipe, for the purpose of disclosing weak spots. The instrument is of the type in which a blow from a 3-5 lb. hammer is transmitted through an anvil, through a bar of known hardness, through an impression ball, to the material being tested. The size of impression made by the ball in the bar of known hardness is then compared with that made in the specimen, using a special microscope provided with the outfit. The hardness is then readily calculated by means of a special slide rule.

Vertical Current Dryer

A DRYER for granular, pasty and liquid materials, which was developed originally in the alkali industry, is now being offered for other service by the Trump Corp., 307 East Fayette St., Syracuse, N. Y. This machine, the Trump Vertex dryer, has also been used for roasting and calcining. It accomplishes any or a combination of these three functions by heat treatment of the material while suspended in an upwardly moving current of heated gases which pass through a vertical tube of gradually increasing cross section. Velocities are adjusted so that materials remain within the dryer until, by loss of moisture, the weight of the particles has been decreased sufficiently to permit their being lifted to the discharge.

Various modifications of construction are employed, depending on the requirements of specific applications. Fundamentally, however, the dryer consists of a furnace for producing hot gases which discharge upward through a tapered tubular drying chamber and thence to a cyclone dust collector, or to a receiving chamber and thence to a cyclone (and bag filter or other collecting device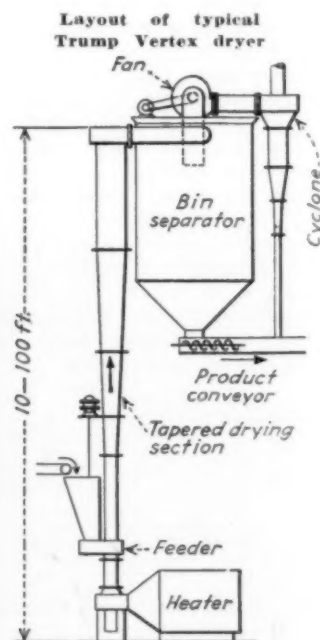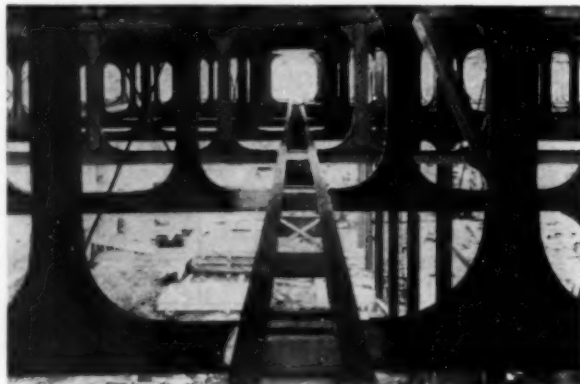, if necessary). Induced draft is generally used, provided by a fan at the discharge of the dust collecting equipment. The feed may be entered into the drying tube at any point, but generally near the bottom. Feed particles up to 1 in. can be handled. An important characteristic claimed for the dryer is that small particles, which dry more quickly, are removed more quickly than larger particles, without over-drying. Larger particles, however, are held longer and subjected to greater turbulence.
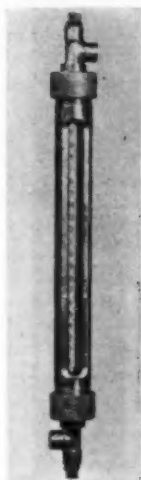
Many advantages are claimed for dryers of this type, among which may be mentioned accurate control of drying conditions, and results, high thermal efficiency, low power consumption, small floor space and adaptability to a wide variety of products.
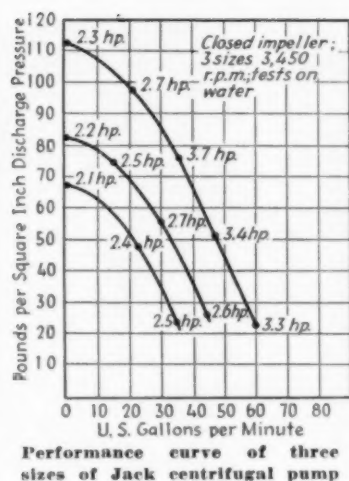
Proportioning Equipment

TWO IMPROVEMENTS in the "hydraulic piston" type of proportioners which it manufactures were recently announced by D. W. Haering & Co., 3408 Monroe St., Chicago, Ill. It will be recalled that this equipment operates on the principle employing two tanks, each

Austin portal trusses during construction of new I.A.C. plant at Chicago Heights, Ill.

Layout of typical Trump Vertex dryer

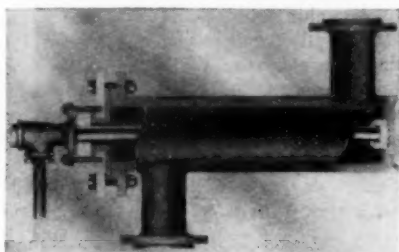Performance curve of three sizes of Jack centrifugal pump

New instrument-type rotameter

New flexible rubber acid bucket

Cutaway view of bayonet type tantalum heat exchanger

connected by a pitot tube to the line carrying the liquid with which reagent is to be mixed. One tube points upstream, the other down. The tank with the upstream tube is filled with a red oil which is immiscible with both the liquid being treated and with the reagent. Entrance of the liquid being treated through the upstream tube forces the oil at a controlled rate into the reagent tank, displacing reagent into the line.

The new Model S feeder is intended for the proportioning of lime and other suspended chemicals and is provided with a motor-driven agitator in the reagent compartment. The new Model WW feeder is similar to the company's standard type except that it is equipped for fully automatic control. Use is made of the relative conductivity of the liquid being treated and of the red oil. When the treated liquid has risen in the red oil compartment to a certain level, the controller operates to alter valve settings, recharge the reagent tank and then puts the equipment back on the line.

Instrument-Type Rotameter

SELLING for considerably less than standard Rotameters, a new instrument-type rotameter recently introduced by the Fischer & Porter Co., 110 West Penn St., Germantown, Philadelphia, Pa., has the tapered glass tube inclosed in a brightly polished brass case. Knurled brass nuts hold the two end fittings in position. The latter are polished copper type fittings. The float consists of a simple ball. The manufacturers expect to find many uses for this flowmeter in applications where the standard type has been considered too expensive.

High-Head Pump

A SINGLE-STAGE centrifugal acid pump for high heads and low capacity has recently been developed and put on the market by Delbert E. Jack, 244 Ninth St., San Francisco, Calif. Originally developed for use in spraying 25 g.p.m. of 10 per cent sulphuric acid at 75 to 100 lb. pressure for weed control in California grain fields, the pump has been found suitable for many chemical plant applications according to its manufacturer. Among these are the pumping of small filter presses, atomizing sprays in absorption towers and similar applications. Construction materials include Durimet (which is stocked), various stainless steels, Alcumite, nickel and other machinable alloys.

An accompanying graph illustrates the performance of this pump in three sizes, using the closed type impeller. Open impellers are also available. It will be noted that the head-capacity curve is steep in comparison with the flat curve typical of most centrifugal pumps. Efficiency is stated to be high, while a recent improvement is claimed to make leakage through the gland practically impossible. Under test, with the packing gland loose, delivering 3 to 5 g.p.m. against 110 lb. pressure, no leak was observed.

Tantalum Heater

FOR HEATING ACIDS and other severely corrosive solutions in circulation, a new bayonet type tantalum heat exchanger has been developed by the Fansteel Metallurgical Corp., North Chicago, Ill. The construction is indicated in the accompanying cut-away view, showing that it comprises an outer jacket made of rubber-lined steel, stoneware, fused silica or other material suitable for the specific requirements, within which is a tantalum bayonet type heating unit. This consists of a simple tube closed at one end and flanged at the other for connection to a base metal tee through which steam is introduced and condensate drained. The heat exchanger may be installed either horizontally or vertically. When installed vertically, the steam connection is at the bottom so that the condensate drains by gravity.

Owing to the inertness of tantalum tubes to practically all acids except hydrofluoric, the heating element retains a high heat-transfer rate except with liquids which form scale. Tests on hydrochloric acid are said to show coefficients as high as 4,000 B.t.u. per sq. ft., deg. F. and hour.

Rubber Acid Bucket

GREATER SAFETY for workmen who handle corrosive liquids is said to be incorporated in a new and improved Flexite acid bucket which has been introduced recently by the B. F. Goodrich Co., Akron, Ohio. This bucket is made of semi-flexible material with a reinforced bead on the base, recessed to permit a firm hold. A capacity scale molded on the inside provides a margin of safety against spillage, also permitting the user to measure quantities accurately. These buckets are available in the 3-gal. size only, weighing 3½ lb. They are provided with metal-reinforced hard rubber handles.

Equipment Briefs

TO SIMPLIFY the operation of floor-operated hoists and cranes, the Harnischfeger Corp., 4400 West National Ave., Milwaukee, Wis., has developed a new push-button variable speed controller for use instead of the pendant rope-operated variable controllers formerly employed. With the new controller there is no danger of a number of control ropes becoming tangled, with the possibility of the incorrect rope being pulled. Five control steps are used. The button element is suspended from the hoist by a multi-conductor cable, within easy reach of the operator. The operator, in depressing a button, starts the motor slowly and as he depresses the button farther, the speed of the motor increases. Any one of the five speeds may be held in either accelerating or decelerating the motor.

THROTTLING CONTROL of electric furnaces and ovens is the function of a new Celectray indicating photo-electric controller, developed by C. J. Tagliabue Manufacturing Co., Park & Nostrand Aves., Brooklyn, N. Y. This instrument employs photo-electric detection of the position of a light beam reflected from a mirror galvanometer toward a reciprocating "controlling edge". The heat

supply is made to vary inversely as the temperature, without measurable dead zone, and without oscillation. The throttling zone can be adjusted within wide limits and there is no appreciable hunting. As a safety feature, power is shut off immediately if the lamp is burned out.

A DRY DISK self-generating photocell of the blocking-layer type has been announced by the Hickok Electrical Instrument Co., Cleveland, Ohio. The active surface of the cell is 1½ in. in diameter, having a sensitivity of about 6 microamperes per foot-candle. A special aging process is used to render the elements permanently stable, the manufacturer stating that continuous exposure to direct sunlight for nine months has revealed no appreciable loss in output.

ADOPTED as standard equipment on its Lightnin portable mixers, the Mixing Equipment Co., Rochester, N. Y., is now employing a sealed ball bearing at the point where the shaft extends from the motor housing. According to the manufacturer, the customary use of a standard ball bearing with bearing retainer, impregnated flax packing, and packing retainer, was satisfactory as long as the proper lubricant was used. However,

48-in. bottom-discharge centrifugal with variable speed drive

Telechron drive of material level indicator

use of a high pressure gun might easily cause trouble. Oil seals and oil traps were tried, but found unsuitable. Finally a pre-lubricated sealed ball bearing of the metal labyrinth type was selected, since it was found that this would retain its lubricant indefinitely, even in a vertical position. Escape of lubricant into the batch being mixed is stated to be absolutely impossible.

Centrifugal Control

ROCHESTER ENGINEERING & CENTRIFUGAL CORP., 110 Buffalo Rd., Rochester, N. Y., announces the development of a simple and accurate method of operation of centrifugals for securing a low, positive unloading speed, for the efficient use of the unloading plow. By reducing the current on the standard extractor motor and driving from the motor to the basket through a simple gear reduction, full power is obtained. The low speed is variable for the efficient handling of whatever product is being centrifuged. The device is used also for securing a low loading speed.

Such centrifugals are also supplied with two-speed motors, thus providing four speeds for loading and unloading.
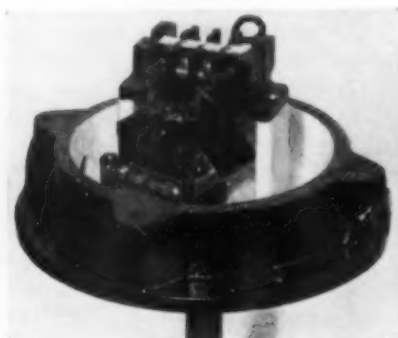
Material Level Indicator

FOR INDICATING the level of solid materials in bins, the Fuller Co., Catasauqua, Pa., has developed and announced a material level indicator which is employed to control conveyor motors,
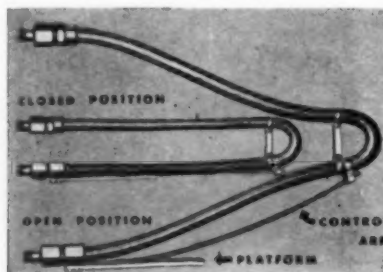

Aluminum alloy shovel

Self-draining hose

valve circuits, etc., or to give audible or visible warnings when the material reaches or falls below a predetermined level in the bin.

The device consists essentially of a dust-tight cover containing mechanism, from which a paddle is suspended in the bin at the desired level. The paddle-supporting shaft is driven continuously at a low speed by means of a Telechron motor, which is supported to turn about the shaft axis. When the level of material reaches and arrests rotation of the paddle, the motor is driven about the axis of the shaft and actuates the switch mechanism.

Aluminum Alloy Shovel

LIGHT WEIGHT, acid resistance and non-sparking character are features of a new line of aluminum alloy scoops and shovels recently announced for chemical industry use by the Wood Shovel & Tool Co., Piqua, Ohio. Weighing only half as much as the usual shovel, they are said to eliminate the handling of two or three tons of dead weight during a continuous day's work. Seven different models and various sizes are available.

Self-Draining Hose

AUTOMATIC REGULATION of the flexing of hose connections for platen presses is accomplished by the new Packless Flex-Control self-draining hose developed by the Packless Metal Products Corp., Long Island City, N. Y. The device consists primarily of a small compact platform and control arm which are rigidly fastened to the lower hose coupling. As the press opens, the arm guides the hose so as to eliminate slack and water pockets at all times. Hose flexing is stated to be equalized and excessive strain eliminated. Three types are available to take care of long or short platen travel and wide, medium or zero opening when in the "closed" position. Hose is regularly furnished with a woven asbestos jacket encasing the bronze hose braid.

Dual Strainer

THE DUOFLO strainer recently announced by Scheffler-Gross Co., Drexel Bldg., Philadelphia, Pa., contains two perforated strainer baskets held in place by covers, so arranged that one strainer can be cleaned without interfering with the operation of the other. A plug cock placed between the two strainer sections is used to deflect the flow from one strainer to the other. This type is used as a suction strainer. A similar line of discharge strainers employs valves instead of a plug cock. The suction type is made in five sizes from 1½ to 4 in., and the discharge type in five sizes from ¾ to 2½ in. Intended primarily for the straining of oil, this equipment is also suited for other liquids.
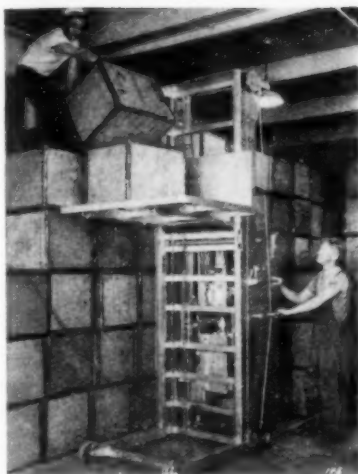
Portable electric lifter handling
crude rubber

Gardner-Denver motor pump

Portable Electric Lifter

SEVERAL INNOVATIONS in design are offered in a new portable electric lifter developed by the Service Caster & Truck Co., 462 Somerville Ave., Somerville (Boston), Mass. Safety features are emphasized. Two heavy duty roller chains, either of which can handle the limit capacity load alone, are used for lifting the platform. A safety hinge is employed for passing through doors and moving under overhead obstructions, enabling the operator to fold over the top section with a few easy turns of a convenient handle. An accurately adjustable travel limiting switch is provided, as well as thermal overload protection for the motor.

Motorized Centrifugal Pump

GARDNER-DENVER Co., Quincy, Ill., announces the perfection of a new close-coupled centrifugal motor pump designed for capacities up to 250 g.p.m. and heads up to 250 ft. at speeds of 1,750 and 3,460 r.p.m. The speed depends on the required capacity and head. Known as Type H, the new pump has been designed to meet requirements of all general pumping service. It is of the single-suction type, having a single-stage enclosed impeller of bronze. An adjust-
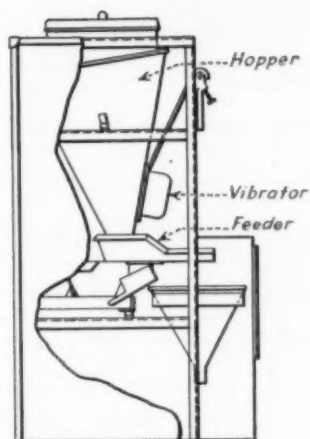
Cabinet-type feeder

able bearing in the outboard end of the motor compensates for wear between the clearance spaces in the pump. No wearing rings are required.

Proportioning Oil Burner

AUTOMATIC PROPORTIONING of air to oil throughout its entire capacity range is the feature of a new industrial oil burner recently introduced after a year's test by the Hauck Mfg. Co., 126 Tenth St., Brooklyn, N. Y. By moving a single lever, air and oil supplies are automatically proportioned, both secondary and primary air orifices being simultaneously adjusted. It is claimed that this burner produces an accurately controlled furnace atmosphere, with CO_2 readings between 13 and 15 per cent at all points of the adjustment range. Several hundred tests are said to have shown fuel savings of 10 to 15 per cent.

Dry Chemical Feeder

A CABINET-TYPE dry feeder for chemicals, for use where an attractive appearance is desired, has been announced by the Syntron Co., 610 Lexington Ave., Homer City, Pa. This device employs this company's vibrating electric feeder to control the rate of flow. The rate is readily adjusted by varying the current to the magnetic conveyor mechanism. Material is stored in a 3-cu. ft. hopper provided with a magnetic vibrator to prevent bridging. Capacities range from less than 100 lb. per hour to as much as 800 lb. on heavy materials.

MANUFACTURERS' LATEST PUBLICATIONS

Alloys. Stainless Steel Division, Smith Steel Foundry Co., 1320 So. First St., Milwaukee, Wis.—Two 4-page booklets giving condensed chemical and physical data on martensitic, ferritic and austenitic stainless steels; and relative corrosive resistance of 18-8 stainless steel to salts, organic materials, acids and common miscellaneous fluids.

Apparatus. Precision Scientific Co., 1750 North Springfield Ave., Chicago, Ill. —Bulletin 221—20 pages on apparatus for testing cement, concrete, lime, gypsum and soils; Bulletin 222, 6 pages on U. S. standard sieves.

Apparatus. Stainless Metals, Inc., 31-49 12th St., Long Island City, N. Y.— Leaflet describing a variety of stainless steel and Monel metal batch cans, scoops, dippers, pails, buckets and measures.

Chemicals. Koppers Co., Koppers Building, Pittsburgh, Pa.—"Koppers Yearbook—1938"—Attractive 30-page illustrated story of the operation and organization of the Koppers Co. and subsidiaries.

Disintegration. Allis-Chalmers Mfg. Co., Milwaukee, Wis.—Bulletin 1473-A —31 pages describing this company's equipment for crushing plants. Includes crushers, screens, washers, motors and similar equipment.

Distintegration. The Jeffrey Mfg. Co., Columbus, Ohio—Catalog 660—47-page booklet describing a number of variations and applications of this company's swing hammer shredders.

Disintegration. Traylor Engineering & Mfg. Co., Allentown, Pa.—Bulletin 1105—13-page booklet describing this company's Type H Blake jaw crusher.

Dust Collection. Buell Engineering Co., 70 Pine St., New York, N. Y.—Attractive 15-page presentation of the Van Tongeren system of fly ash collection. Gives descriptions and operating data.

Dust Collection. Connecticut Blower

Co., Box 884, Hartford, Conn.—Bulletin 63—4 pages illustrating and describing this company's industrial vacuum cleaning systems.

Economizers. Combustion Engineering Co., Inc., 200 Madison Ave., New York, N. Y.—Catalog EE-5—16-page catalog deals with latest designs and details of this company's Elesco fin-tube economizers; also discusses factors governing selection and application of economizers.

Ejectors. Westinghouse Electric & Manufacturing Co., Philadelphia, Pa.— Folder 8446—6-page illustrated leaflet, describing this company's single- and multi-stage steam jet air ejectors.

Electrical Equipment. Burke Electric Co., Erie, Pa.—6-page leaflet describing this company's polyphase induction motors. Includes new pivot type for self-adjustment of belt tension.

Electrical Equipment. General Electric Co., Schenectady, N .Y.—GEA-1724A— 16-page pamphlet describing construction, operation and applications of this company's controllers for synchronous motors; GEA-2026A, 4-page leaflet describing construction, operation and applications of this company's a.c. brake motor.

Electrical Equipment. Harnischfeger Corp., Milwaukee, Wis.—Bulletin M-2— 8-page leaflet describing design and construction of this company's convertible slip-ring motors, standard wound-rotor type.

Electrical Equipment. Sterling Electric Motors, Inc., Telegraph Road at Atlantic Blvd., Los Angeles, Calif.— Bulletin 142—4-page leaflet describing improvements in this company's enclosed motor.

Equipment. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.—Price list 15-010—13-page leaflet entitled "Type HD Heavy-Duty Push-Button Station".

Filters. Oliver United Filters, Inc., 33 West 42d St., New York, N. Y.—Bulle-

tin 240—4 pages describing this company's rotary vacuum filter for dewatering sewage sludge.

Fittings. Alloy Steel Products Co., Linden, N. J.—18-page catalog describing this company's Aloyco stainless steel valves and fittings. Gives section view, construction, standard sizes and materials for each type.

Heat Exchangers. The Duriron Co., Dayton, Ohio—Bulletin 1601A—8 pages on the construction and operation of Duriron heat exchangers for corrosive liquids; Bulletin 1202A, 8 pages describing Duriron Kjeldahl equipment.

Heat Exchangers. Griscom-Russell Co., 285 Madison Ave., New York, N. Y. —Bulletin 1260—8-page illustrated leaflet describing more than 20 designs of this company's chemical industry heat exchangers. Table recommends types for special fluids and services.

Instruments. The Bristol Co., Waterbury, Conn.—Bulletin 513—4 pages describing this company's Metavane system for remote recording and control of flow, temperature, pressure and liquid level.

Instruments. Brown Instrument Co., Philadelphia, Pa.—Folder 89-9—6-page leaflet listing and illustrating applications of this company's air-operated control equipment.

Instruments. The Foxboro Co., Foxboro, Mass.—Bulletin 184-2—32-page bulletin describing this company's electrically operated control instruments for two-position control applications.

Instruments. National Technical Laboratories, 3330 East Colorado Blvd., Pasadena, Calif.—Bulletin entitled "The Determination of Neutralization Numbers of Oil Products with the Beckman pH Meter."

Instruments. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.—Catalog section 31-260—12-page booklet, developing the application, operation, construction and features of "Silverstat" regulators designed for automatic voltage control of small a.c. and d.c. generators.

Insulation. Armstrong Cork Products Co., Building Materials Div., Lancaster, Pa.—37-B-6—32-page booklet describing this company's cork covering for cold lines and cylindrical tanks; includes directions for applying covering, also heat loss tables. No. 37-B-4, 28 pages describing corkboard insulation for cold storage rooms and correct methods for application.

Insulation. Refractory & Insulation Corp., 381 Fourth Ave., New York, N. Y. —Bulletin I-63—Leaflet describing this company's diatom-asbestos-composition insulating blocks.

Lighting. United Cinephone Corp., 43-37—33d St., Long Island City, N. Y. —Leaflet illustrating and describing this company's special industrial lighting reflectors.

Materials Handling. Elwell-Parker Electric Co., Cleveland, Ohio—32-page booklet illustrating the leading types and models of Elwell-Parker trucks, tractors and cranes.

Materials Handling. The Fairbanks Co., 393 Lafayette St., New York, N. Y. —Catalog No. 52—46 pages illustrating and describing this company's hand trucks, wagons, barrows, carts, lift trucks, and portable elevators for all purposes.

Materials Handling. Jeffrey Mfg. Co., Columbus, Ohio—Folder 689—Folder describing this company's three-pulley and five-pulley belt idlers.

Materials Handling. Link-Belt Co., 300 West Pershing Road, Chicago, Ill.—Book No. 1510—32 pages of ideas and suggestions for cutting handling costs in power plants by means of elevators, conveyors, coal crushers and similar equipment.

Materials Handling. Manhattan Rubber Mfg. Div., Raybestos-Manhattan, Inc., Passaic, N. J.—Bulletin 6869—Bulletin describing this company's Condor whipcord endless belts with patented splice.

Mixers. National Engineering Co., 549 West Washington Blvd., Chicago, Ill.—16-page catalog describing principles, advantages and variations of this company's muller type mixers.

Power Transmission. Poole Foundry & Machine Co., Baltimore, Md.—Catalog 38—70-page booklet describing this company's flexible shaft couplings, with engineering data and information on types and applications.

Pumps. DeLaval Steam Turbine Co., Trenton, N. J.—Catalog B-3—11-page leaflet describing this company's series of opposed impeller centrifugal pumps.

Pumps. Pomona Pump Co., Pomona, Calif.—6-page story of recent developments at this company.

Pumps. F. J. Stokes Machine Co., Olney P. O., Philadelphia, Pa.—Catalog 38-P—28-page booklet giving useful engineering data on high vacuum practice and describing five sizes of Stokes high vacuum pumps.

Refractories. Harbison-Walker Refractories Co., Pittsburgh, Pa.—8-page folder describing this company's "Alamo" and "Varnon" super-duty fireclay brick.

Refractories. Johns-Manville, 22 East 40th St., New York, N. Y.—Form DS, Series 700—20-page technical data book giving detailed information on refrac-

tory products, including cements, castables and plastics. Gives 4-page recommendation table.

Safety. American Optical Co., Southbridge, Mass.—4-page leaflet illustrating correct procedure for fitting eye-cup goggles and flexible type goggles for greatest comfort and safety; suitable for posting on bulletin boards.

Safety. Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh, Pa.—Bulletin ED-3—6-page leaflet describing in detail this company's line of industrial gas masks

Separators. Stearns Magnetic Mfg. Co., Milwaukee, Wis.—Bulletin 700—Pamphlet describing this company's Type K induction separator for concentration of ores, minerals and other materials of high magnetic reluctance; Bulletin 25, pamphlet describing this company's line of circular, rectangular and hand magnets for magnetic separation and other special purposes.

Traps. American District Steam Co., North Tonawanda, N. Y.—Bulletin 35-86 —4 pages on construction and installation hook-ups of this company's float-type steam trap.

Turbines. Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. —B-2137—12-page illustrated booklet describing Westinghouse Type C general purpose turbines in capacities from 5 to 500 hp. at 1,000 to 5,000 r.p.m.

Welding. Harnischfeger Corp., Milwaukee, Wis.—Bulletin R-5—27-page booklet giving detailed information on each of this company's types of Smootharc welding electrodes.

INTERPOLATION SCHEDULE

work with but four sets of values, two on either side of the desired point. The tabular schedule appears in Fig. 2.

The figures appearing in the + and — columns were evaluated as follows:

$$264 \; \frac{(1)\,(-1)\,(-2)}{(-1)\,(-3)\,(-4)} = - \; 44.0$$

$$1024 \; \frac{(2)\,(-1)\,(-2)}{(1)\,(-2)\,(-3)} = \; 682.7$$

$$2679 \; \frac{(2)\,(1)\,(-2)}{(3)\,(2)\,(-1)} = \; 1786.0$$

$$3561 \; \frac{(2)\,(1)\,(-1)}{(4)\,(3)\,(1)} = - \; 593.5$$

$$\overline{\hspace{2cm} 1831.2}$$

Thus it is seen that f' at $P' = 4$ is 1831 and that $f = 1.1831$ at $P = 400$. The nature of the symmetry can best be grasped by a study of the two units. In the denominator unit the factors on opposite sides of the diagonal show opposite signs. This is not the case with the numerator unit.

The value of the compressibility factor at 400 atm. is given in the original data as 1.1833. Using all six pairs of f, P

data the La Grange formula yields the exact value, 1.1833. The data chosen should lie evenly on both sides of the interpolated point. When this is not the case slight errors result. For instance, when f is interpolated for $P = 400$ from the 100, 200, 300, and 500 atm. data it is found to be 1.1841 and when interpolated from the 300, 500, 600, and 800 atm. it is 1.1823. Mere plotting of the points and construction of a curve yields $f = 1.1820$ when 1 cm. is chosen to represent 0.0200 in f and 50 atm. in P.

Averaging of the two points on either side of the desired value yields 1.1852, seriously in error. When two pairs of such points are averaged the result is 1.1842. The empirical equation

$$y = 10^{ax+b} + c$$

where $a = 0.024457$, $b = 0.067538$ and $c = -0.2810$ fits the data very closely and yields 1.1831 for f at $P = 400$. This is identical with the four-point interpolation by the La Grange method and is entirely satisfactory except that considerable time and labor are necessary to determine the equation, which however, serves for any number of interpolations. The various interpolated values are given for comparison in the accompanying table.

Interpolation of f at $P=400$ Atm.

Method	f	Deviation
Averaging of f at $P = 300$ and $P = 500$	1.1852	0.0019
Averaging of f at $P = 200$, 300, 500, and 600	1.1842	0.0009
From a careful plot of f vs. P	1.1820	—0.0013
Empirical equation, $y = 10^{ax+b} + c$	1.1831	—0.0002
La Grange formula, P at 100, 200, 300, and 500	1.1841	0.0008
La Grange formula, P at 300, 500, 600, and 800	1.1823	—0.0010
La Grange formula, P at 200, 300, 500, and 600	1.1831	—0.0002
La Grange formula, P at 100, 200, 300, 500, 600, 800	1.1833	0.0000
From the original data	1.1833	

Educators Attack Problems Of Specialization

Of about 1,000 engineers and engineering educators who met at Texas A. & M. College, June 27-30, for the 46th annual meeting of the Society for the Promotion of Engineering Education, approximately 60 participated in the three-day conferences on chemical engineering. Chairman of the division Olaf A. Hougen of Wisconsin presided over an important discussion of the question: "Is the chemical engineering curriculum an adequate training for specialized industries?" Papers by B. F. Ruth of Texas A. & M., Paul M. Horton of Louisiana State University, R. L. Huntington of the University of Oklahoma, and W. E. Bradt of the University of Maine described the status of specialized courses in sugar, petroleum and paper technology. Robert M. Boarts of the University of Tennessee lead the discussion which clearly indicated that trend is away from such courses. Professor Horton pointed out that at L.S.U., for example, the very comprehensive facilities of the sugar house are used primarily to teach the unit operations of chemical engineering rather than sugar technology as such. Professor Ruth's paper quoted excerpts from letters in which industrial employers were almost unanimous in condemning the practice of teaching applications rather than fundamental principles.

Vice-chairman R. C. Kintner of Armour Institute presided at sessions where more than a dozen papers were presented on details of various courses in the present curriculum. E. E. Randolph of North Carolina State College discussed recent developments in chemical engineering education in Europe. Thomas H. Chilton of the duPont company pointed the way toward better coordination of research activities in the universities with those of industry by describing the type of chemical engineering problems most suitable for investigation in college laboratories. Of the unit operations he listed the following as in most need of fundamental study: mixing and agitation, absorption, leaching and extraction, evaporation, crystallization, distillation, adsorption, drying and impregnation.

Dr. Charles Cleveland Hedges head of the Department of Chemistry and Chemical Engineering at Texas A. & M. proved a genial host and resourceful toastmaster at the banquet of the chemical engineering division. He announced that next year's meeting would be held at Pennsylvania State College.

Plastics Will Feature Fall Meeting of Electrochemists

Two special symposia have been placed on the program for the fall meeting of The Electrochemical Society, Inc., which will be held at Rochester, N. Y., Oct. 12-15. The Hotel Seneca has been selected as headquarters.

Dr. S. O. Morgan, Bell Telephone Laboratories, Summit, N. J. will preside over the session on "Plastics in the Electrochemical Industry." Among the papers to be presented are: "Classification of Commercial Organic Plastics and Their Chemical Properties" by Gordon M. Kline, U. S. Bureau of Standards; "Thermosetting Plastics" by V. E. Meharg, Bakelite Corp.; "Methacrylate Resins" by H. R. Dittmar, E. I. du Pont de Nemours & Co.; "Vinyl and Styrene Resins" by S. D. Douglas, Carbide and Carbon Chemicals Corp.; "Ethyl Cellulose and Styrene Plastics" by Shailer L. Bass, Dow Chemical Co.; "Dialectric Constant and Loss of Plastics as Related to Their Composition" by W. A. Yager, Bell Telephone Laboratories; "Electric Properties of Polyvinyl Chloride Plastics" by R. M. Fuoss, General Electric Co.; and "Dielectric Properties of Shellac" by Erik Ackerlind, Brooklyn.

The second symposium will be devoted to "The Metallurgy of Silver" under the supervision of Dr. Lawrence Addicks, Bel Air, Md. Among the authors of papers to be submitted are: Dr. F. C. Mathers, Dr. Colin D. Fink, V. S. de Marchi, and Dr. D. K. Alpern.

New Chemical Engineering Laboratory for Case

William E. Wickenden, president of Case School of Applied Science, Cleveland, Ohio, has announced that construction will start at once on the first unit of a laboratory of chemical engineering which, when completed will cost approximately $750,000.

According to Professor C .F. Prutton the unit to be constructed at the present time will provide principally for the distinctly engineering features of the Department. The basement will include a large industrial process laboratory 80 by 40 feet, additional grinding, drying and research laboratories, an instrument room, and maintenance and repair shops. The extension will have 35 feet of headroom with a balcony at the 17-foot level covering about half the area. Special booths of reinforced concrete will be provided for experiments involving inflammable, explosive or high pressure reactions.

The first floor of the main structure will have a large senior laboratory of 45 by 85 feet where plant development problems and thesis projects will be handled. This laboratory will handle 64 men at the beginning and provision is made to expand its capacity to 80. A complete shop will be provided where students may construct their own apparatus. A furnace room for heat reaction experiments, a precision weighing room, research rooms and offices will also be located on this floor.

The two upper floors will provide an organic laboratory 60 by 45 feet with an ultimate capacity of 96 students, a fuel laboratory 60 by 20 feet, a laboratory of physical chemistry, recitation rooms, offices and research laboratories.

Distilled water apparatus and ventilating equipment will be placed in a penthouse on the roof. Contaminated air from the laboratories will be completely renewed every four minutes. Unit steam heaters will be employed during the winter months.

Simplified Package Sizes For Insecticides

The current revision of Simplified Practice Recommendation R41, Package Sizes for Agricultural Insecticides and Fungicides, has been accorded the required degree of acceptance by the industry and is effective from June 15, 1938, according to an announcement of the Division of Simplified Practice, National Bureau of Standards. The revised recommendation will be identified as Simplified Practice Recommendation R41-38.

This recommendation not only lists the types and sizes of packages for certain items but also indicates the number of packages to be placed in shipping box. The geographical area for which each size and type of package is particularly adapted, is also given.

National officers of Alpha Chi Sigma—V. W. Meloche, University of Wisconsin, Grand Master Alchemist; W. P. Higburg, Reilly Tar & Chemical Co., Indianapolis, Grand Professional Alchemist; H. P. Gaw, American Rolling Mill Co., Middletown, Grand Master of Ceremonies; W. S. Ritchie, Massachusetts State Agricultural College, Amherst, Grand Collegiate Alchemist; J. R. Kuebler, Shortridge High School, Indianapolis, Grand Recorder

Alpha Chi Sigma Meets At New Orleans

Addressing three hundred members and guests of the Alpha Chi Sigma chemical fraternity at their 15th biennial conclave in New Orleans on June 21, Commodore Ernest Lee Jahncke, executive director of the Louisiana State Department of Commerce and Industry, declared that more than 150 manufacturing industries had either opened new factories or expanded existing plants in Louisiana since the inauguration of the state's new industrial program. A large proportion of these are chemical process industries which have added more than 20,000 employees and $50,000,000 of new industrial investments.

To accomplish this industrialization the director said "We are employing as a means of expressing our desire to give state cooperation to industry, an amendment to our constitution which offers all new industries a 10-year period of exemption from property taxation. As a further inducement our administration has assured industry of complete freedom from political and legislative interference which it has unhappily experienced in some other sections of the country."

Further evidence of Louisiana's chemical prosperity was noted in Baton Rouge when the fraternity visited this important center on June 23. The chemical engineering department of Louisiana State University has been given one of the most complete unit operation laboratories in the United States. Small, semiworks and full scale equipment have been installed for all types of investigation. At Istrouma, just north of Baton Rouge the huge new plant of the du Pont company is nearing completion while impressive expansion programs are under way in the adjoining plants of the Solvay Process Co. and the Standard Oil Co. of Louisiana.

Numbering almost 14,000 in membership, with more than 50 college chapters and with active professional groups in the principal centers of chemical industry, Alpha Chi Sigma has become one of the strongest and most resourceful of the professional fraternities. Aside from its undergraduate activities in promoting better scholarship, it is proving a useful and constructive influence in professional guidance and development among its alumni members.

AAA Funds May Finance Regional Laboratories

For some time near the end of the Congressional session, it appeared that the $4,000,000 regional laboratories of the Department of Agriculture would not be established because Congress was not providing the necessary money in the regular appropriation bill for the department. Then it developed that the form of the original law establishing these laboratories made A.A.A. funds automatically available for them by mere allocation by the Secretary. Hence an elaborate program was being worked out largely in the Bureau of Chemistry and Soils, but with the aid of the various other bureaus and divisions of the Department.

It is now expected that a Southern laboratory to deal primarily with cotton and a Northern laboratory to deal with corn, grain, and other feeding stuffs will be established fairly soon. No definite program for the Western laboratory has been fixed, but it will not surprise if it should deal largely with food processing and food byproducts. The Eastern laboratory will necessarily devote itself to the commodities and problems of importance in the use of agricultural surpluses of the Eastern seaboard, such as apples, skim milk, tobacco. Congress has instructed the Department to prepare an elaborate statement of the program which it intends to undertake in these laboratories and report to Congress next year.

A.C.S. Will Hold Ninety-Sixth Meeting in Milwaukee

Dr. Henry B. Merrill, former chairman of the Division of Leather and Gelatin Chemistry of the American Chemical Society, has been appointed general chairman of the Society's ninety-sixth meeting, to be held in Milwaukee, Wis., Sept. 5 to 9.

Seventeen professional divisions and the microchemical section of the Society have scheduled scientific sessions devoted to virtually every branch of chemistry. The Division of Industrial and Engineering Chemistry will sponsor three symposia dealing with "Surface Active Agents," "Unit Processes," and "Electrical Insulating Materials." Eight other symposia during the five day meeting will include: "Industrial Utilization of Agricultural Products," by the Divisions of Agricultural and Food and Biological Chemistry; "Vitamins" and "Patents," also by these two Divisions together with the Medicinal Chemistry Division; "The Physical Chemistry of Proteins," by the Colloid Chemistry and Physical and Inorganic Chemistry Divisions; "Nomenclature of the Sugars and Their Derivatives," by the Sugar Chemistry and Organic Chemistry Divisions; "Nuclear Chemistry," "Determination of Traces," and "Reactions in Liquid Ammonia," by the Division of Physical and Inorganic Chemistry.

Price Fixing Charged to Cottonseed Industry

The Joint Executive-Congressional Monopoly Committee has been asked to include the cottonseed industry in its antitrust investigations. Representative John E. Rankin of Mississippi charged that there was a conspiracy looking toward fixation of prices for cottonseed which would cost southern and other cotton planters anywhere from $100,000,000 to $300,000,000. He further charged that a lowering in prices for cottonseed would depress values for other agricultural and dairy products which come into competition with cottonseed products.

ADMINISTRATION of new laws and investigations by special committees of Congress now dominate Washington planning. But the departure of Congress has not in any way reduced the political aspect of all this activity. Not even the "non-political" speech-making trip of President Roosevelt to the West Coast is accused of being without party or reform significance.

Congress departed after a session that was record making in many respects. It appropriated more billions than ever before in a peace-time session. And it enacted more bills of large economic or social significance than have probably been enacted in a like short period, except perhaps the first session following the accession of Roosevelt in 1933.

Those laws not passed and the few vetoed by the President have died. But they will come to life again in the next Congress with much of the momentum of this year remaining, unless November elections radically shift the character of the next Congress away from reform and New Dealer policies.

Laws Passed, and Failed

Of the many bills which passed Congress late in the session, the President approved the vast majority. Only two of general public importance were vetoed. One of these, the stream pollution measure, was of large significance to chemical process industry. That item the President disapproved because the proposals of the Public Health Service regarding corrective measures were to go direct to Congress without passing through the Budget Bureau and under Presidential scrutiny. Under the guise of economy and coordinated budgetary practice, the President said that the Chief Executive could not have this sort of executive matters handled directly by the legislative branch.

New authority was given the Federal Power Commission to regulate rates and services in the transportation and sale of natural gas in interstate commerce. This is a long step toward the regulation of a natural resource industry and one which may affect prices charged by natural gas producers to big industrial customers. It extends the Federal influence much farther into utility matters than heretofore.

Bills of interest to chemical industry which failed included: Truth in fabrics measure; anti-chain-store legislation (forbidding manufacturers to sell at retail); establishment of stock piles of strategic minerals and metals; license control of exports of scrap metals and materials; processing taxes, largely on foods, but partly on agricultural materials used in chemical industry; reorganization of the government; economic planning; export subsidy intended to stimulate export of raw materials with the claimed possible disadvantage of restricting foreign markets on manufac-

NEWS FROM WASHINGTON

Washington News Bureau
McGraw-Hill Publishing Co.
Paul Wooton, Chief

tured goods; various patent and trade mark bills.

Phosphate Study

Near the end of the session Senator Pope put the pulmotor on the legislation proposing the phosphate inquiry and secured enactment and Presidential approval. Three members of the Senate and three from the House initiated hearings in Washington immediately after Congress adjourned. They then recessed to reconvene in Idaho, July 20. Even critics of these investigations were favorably impressed by the initial sessions. A serious effort to secure knowledge regarding the economic prospect and problems involved in Western phosphate processing is now expected. It appears unlikely, however, that the building of any large phosphate works in the West will be planned for an early date. Experimental studies may be undertaken in Idaho, but are expected to be limited to small-scale studies since practically nothing which can be done on a semi-works basis could not be equally well or better done by shipping a limited amount of additional Western rock to the laboratories of T.V.A.

The anti-monopoly inquiry also has surprised Washington observers by the moderate fact-finding style in which it has been undertaken. Chairman O'Mahoney, Senator from Wyoming, insists that no "witch hunting" need be expected. The committee of 12 has organized in pairs, one member of Congress with one member from the departments to be assigned to each subcommittee job. A serious effort to formulate a basis for new legislation next year, rather than headline hunting and political campaigning, appears the order of the day. Mentioned as likely to receive special attention, possibly new anti-trust action, are: Steel, cement, petroleum, aluminum, and rubber.

Work of the T.V.A. investigating committee continues to be conducted quietly. It is not expected that any important public hearings will be held until early Fall.

Permanent Records

Assisted by representatives of library, commercial, and other Government agencies, the Bureau of Standards has been carrying out investigations and a series of conferences on the permanence of various types of photographic films when used for library or documentary purposes. Lacking knowledge of the aging properties, a series of accelerated aging tests have been carried out by heating the films at 100 degrees C. for varying periods. The Paper Section of the Bureau states some of its findings, as follows:

Two types of films comprising three kinds of bases have been studied. One type was nitrate or acetate base coated with photographic emulsion. The other was a viscose base impregnated with a light-sensitive dye for forming the image. After heating, the films were tested for loss of folding endurance, degradation of the cellulose, and gain in acidity; all evidences of deterioration. All the tests showed the same thing: that good acetate base has stability comparable with that of high-grade paper; that the nitrate base is very unstable; and that the viscose base is intermediate, being similar to medium-grade paper in stability.

It was stated that the Bureau, therefore, believes high-grade acetate film to be suitable for permanent records and that the dye type of film with the viscose base should find considerable use for positive prints to be used in reading rooms. The latter type is of particular interest in that it is grainless, gives high contrast, is much thinner than the emulsion type, and the image is not so susceptible to damage by wear since it is contained in the base instead of in an emulsion.

New Labor Laws

The wage-hour standards established by the new law take effect early this Fall. Nominally, a minimum wage of 25 cents an hour and a maximum work period of 44 hours per week are fixed initially. Stepwise, the act provides for approach to the 40-40 base in 7 years. But, a fact many have overlooked is that the new administrator of the Fair Labor Standards Act, when named, may fix 40 hours and 40 cents effective almost immediately in any particular industry. The attitude of this administrator and of his cooperating industry committees will, therefore, be vital in determining the speed with which the floor of wages and the ceiling of hours may approach their ultimate objective.

Various other items of labor legislation which failed in the last Congress will be taken up again next year.

HIGH RATE OF INDUSTRIAL PRODUCTION IN GERMANY DESPITE DROP IN EXPORTS

From Our German Correspondent

ALTHOUGH Germany's exports have dropped since the beginning of the year, industrial production, especially for the first quarter, has been maintained at a high level. Annual reports of various large industrial concerns which have recently been published show considerable production increases for such firms as the Mitteldeutsche Stahlwerke, the Lautawerk Aluminum Co., The Harpener Bergbau Co., the Essener Steinkohlenbergwerke, and other coal companies, the Ruhr Gas A. G., Essen, and various cement companies. Whereas world coal production is still 35 million tons below 1929, the German production of 185 million tons in 1937 was 15 per cent above the previous year and 21 million tons above the 1929 peak.

Staple fiber, or "cell wool," production in Germany grew from 46,000 tons in 1936 to 100,000 metric tons for 1937, thereby giving Germany the lead in this field, although when rayon is included, Japan still heads the world in total synthetic fiber output. The ratio of staple fiber to rayon production for the whole world rose last year to 1:2 as contrasted to 1:3 in 1936, and Germany increased her lead over Italy and Japan. By the end of this year, Germany's staple production will have reached 150,000 tons, which will be equivalent to 40 per cent of the German textile industry's requirements of cotton and wool in the year 1930.

Although German wood fiber processes are being adopted in countries with rich forests, dairying countries are favoring the Italian Lanital processes. The leading Italian corporation, Snia Viscosa, whose recently announced profits for 1937 topped those of 1936 by far, has reported new textile casein plants projected or already built in Holland, Belgium, France, Poland, and Norway. The Lanital fiber is more like natural wool and looks like a good Merino quality, and it is now reported to be 85 per cent as strong as natural wool as contrasted with only 10 per cent a few years ago. It is claimed that it will generally withstand water and moisture, does not shrink, and is not attacked by moths. However, it is not as fluffy as natural wool, and Lanital is usually mixed half and half with the natural product. It has been used to best advantage for ladies' light clothing fabrics, felt hats, knitted goods, and technical felts.

Even though without colonies of her own, Germany is investigating the suitability of utilizing fibers from tropical woods. In a recent report before the Verein der Zellstoff und Papier-Chemiker in Berlin, Dr. von Movroy announced that new possibilities in the textile use of tropic wood are being developed. Eucalyptus, for example, has been found to yield a textile fiber with unusual absorbent qualities, and South African long-fibered Aurakarie may be used for direct spinning.

The Zellstoffabrik Waldhoff, one of the largest cellulose manufacturers in Germany, reported a 9 per cent increase in cellulose production last year. The cellulose output of its Kostheim plant was trebled last year, and its Rognitz plant in East Prussia extended its program to inclue synthetic fiber cellulose production, and during the course of 1938 the concern plans to change its basis of production from pine to domestic beech woods.

The new I. G. Farben fiber which is a vinyl polymerization product like Igelit is now being manufactured commercially. It can be used for acid- and alkali-resisting filters, diaphragms for electrolytic processes, and can also be woven into a fabric suitable for protective clothing to be worn in the chemical industry.

For the building of a number of wood sugar plants, the Thuringian Gas Gesellschaft, with the participation of the city administration of Coblenz, has formed the Holzverzuckerungsgesellschaft m.b.H.

A Swedish process for manufacturing gasoline and lubricating oils from wood as well as byproducts like toluol, cymol, etc., is now to be applied on a commercial scale in a plant to be erected by the beginning of next year in southern Sweden. The process is said to be relatively simple, and raw material of wood shavings as well as wastes from cellulose factories, charcoal and wood tars is to be used.

Professor Franz Fischer announces that through applying moderate pressure in the Fischer-Tropsch gasoline synthesis, it has been possible to increase the yield of the byproduct paraffine from 8 to 50 per cent. This announcement is of importance to the German soap industry, where paraffine is being oxidized by the Imhausen process to make fatty acids. The Witten Company in the Ruhr with a yearly capacity of 20,000 tons, is constructing two new plants so that by the end of 1938 production of synthetic fatty acids should reach 60,000 tons. This will help slightly to relieve fat and oil imports which now amount to approximately one million tons, a quarter of this being required for the soap industry.

The major part of Germany's synthetic gasoline from coal is being made according to the Fischer-Tropsch and I. G. Farben processes. In the Ruhr, however, the low-temperature carbonization processes have been disappointing. After trial operations with two other processes proved unsatisfactory, the "Vereinigung zum Studium der Steinkohlenverschwelung" has announced that it will build a new pilot plant at one of the Hoesch mines, with a daily capacity of 20 to 25 tons of hard coal, using the gas washing processes which have been successful with lignite.

Experiments conducted last year by German wine growers to recover oil from grape husks are reported to have been successful, even though not overly economical. With only part of the residue of the grape crop in the Rhine being treated, 40,000 liters of oil were produced from the seeds, and it is estimated that the whole grape crop in Germany would yield one million liters of oil a year.

Domestic oil productions from grape seeds dropped by 21 per cent last year as a result of lower yields per acre and crop damage from weather. With flax production increased, the linseed yield was up 29 per cent, and the less important hemp seed crop was up 46 per cent.

Complaints of a deterioration in quality of leather tanned with synthetic sulphite cellulose extracts have resulted in renewed investigation, the results of which were reported recently at the annual meeting of the Kaiser Wilhelm Institute for Leather Research in Dresden.

The Institute has also worked out a successful tanning process to make leather from the skin of cod, haddock, catfish, etc. In Wesermuende near Bremen, a plant which can process a ton of fish leather a week has already been established. Although very smart looking ladies' shoes are being made from the fishskin leather, it obviously lacks the wearing qualities of other leathers.

Cooperation between the British and German chemical industry has been further strengthened through the announcement of the establishment of the Trafford Chemical Co., Ltd., by I. G. Farbenindustrie and Imperial Chemical, Ltd. I. G. Farben patents are also to be used in a new cellulose factory which is projected in Szolnok in Hungary. It is reported that the cellulose is to be used chiefly for rayon manufacture.

A new and improved silicium enamel coating for apparatus and containers used in chemical and allied industries has been announced by the Gebler Werke A. G., Radebeul-Dresden. Among the advantages claimed for the new silicium enamel is that it is resistant to all organic and inorganic acids, except hydrofluoric, that it is elastic and can be subjected without damage to rapid temperature changes, and that it is a good heat conductor and will withstand extremely hard mechanical tests.

PERSONALITIES

Ellery L. Wilson

✦ ELLERY LEWIS WILSON, vice-president of the Rumford Chemical Co. in East Providence, R. I., died at Pomfret, Conn., June 26, at the age of 57. Mr. Wilson was a director of the company and superintendent of its manufacturing plant in East Providence. He was a past president of the Providence Engineering Society and prominent in the American Institute of Chemical Engineers where he held a directorship at the time of his death as well as membership on several committees. He was also the Institute representative on the National Research Council.

✦ HUBERT B. BRAMLET, captain, Chemical Warfare Service, has been transferred from duty in the New York Procurement District to foreign service in the Panama Canal Zone.

✦ A. E. CHESTER has left the Ferro Enamel Corp., Cleveland, Ohio, to join the Peerless Equipment Corp. of Chicago.

✦ KENNETH H. DONALDSON has been appointed head of the department of metallurgical engineering at Case School of Applied Science, Cleveland, Ohio. For the past few months Professor Donaldson has been acting as temporary head of the department, taking over the duties in February from Prof. Herbert M. Boylston, who was granted leave of absence due to ill health.

✦ GEORGE H. DUNCOMBE, JR., formerly engineer with the National Aluminate Corp., has joined the staff of Battelle Memorial Institute, Columbus, Ohio, and has been assigned to research in ceramics.

✦ A. R. KEMP of the Bell Telephone Laboratories attended the National Rubber Technology Conference at London, May 23-25, as official delegate of the Rubber Division of the American Chemi-

cal Society. Mr. Kemp was a member of the Papers Committee for the meeting.

✦ HENRY D. LYTTON, formerly of the International Statistical Bureau of New York, has been appointed research director of the General Tung Oil Corp.

✦ HERBERT R. MOODY, professor of chemistry at the College of the City of New York, will retire in August to Vienna, Va., after 33 years service at City College.

✦ WILFRED PAQUIN has been added to the research staff of the Ferro Enamel Corp., Cleveland, Ohio, where he will study the properties of domestic clays with particular reference to their suitability for use in porcelain enamel.

✦ EDWIN M. RUPP has become associated with the National Engineering Co. and will devote his time to the development and sales of mixing equipment for use in the ceramic, clay and refractory industries.

✦ J. J. D. RUTHERFORD, formerly of the research laboratory of U. S. Steel Corp. at Kearney, N. J., has joined the staff of Babcock & Wilcox Tube Co. as research metallurgist.

✦ R. B. SCHAUSS has joined the research staff of the Ferro Enamel Corp., Cleveland, and will study the applications of wet process leadless enamel to cast iron.

✦ HOWARD V. SMITH, for the past eleven years assistant superintendent of the El Dorado Refinery of the Skelly Oil Co., has been appointed chief chemical engineer of the Barber Asphalt Corp.

✦ WALTER A. WISANSKY, Columbia University Ph. D. 1938, has joined the staff of the Herstein Laboratories, Inc., New York City, as a research assistant.

HONORS

✦ NEWCOMB KINNEY CHANEY, of the United Gas Improvement Co., Philadelphia, has been awarded the Howard N. Potts gold medal by the Franklin Institute.

✦ ROBERT H. HEYER, JR., research metallurgist for the American Rolling Mill Co., received the Charles B. Dudley medal for 1938 at the recent A.S.T.M. annual meeting in Atlantic City.

✦ HARRY B. MELLER, managing director of the Air Hygiene Foundation, Pittsburgh, received the honorary degree of Doctor of Science from the University of Toledo.

✦ GEORGE W. MERCK, president of the chemical manufacturing firm of Merck & Co., Rahway, N. J., received the honorary degree of Doctor of Pharmacy at the 116th annual commencement of the Philadelphia College of Pharmacy and Science.

✦ THEODORE SWANN, president of Swann & Co., chemical manufacturers of Birmingham, Ala., received the honorary degree of Doctor of Science from the University of Alabama.

✦ ROGER WILLIAMS, chemical director of the Ammonia Department of E. I. du Pont de Nemours & Co., received the honorary degree of Doctor of Science at the commencement exercises of West Virginia University, Morgantown, W. Va.

○ CALENDAR ○

SEPT. 5-9, AMERICAN CHEMICAL SOCIETY, Milwaukee, Wis.

SEPT. 8-10, TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY, semi-annual meeting, Green Bay, Wis.

OCT. 12-15, ELECTROCHEMICAL SOCIETY, Hotel Seneca, Rochester, N. Y.

NOV. 9-11, AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, annual meeting, Philadelphia, Pa.

DEC. 5-10, THIRTEENTH NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING, Grand Central Palace, New York City.

APRIL 16-21, 1939, AMERICAN CERAMIC SOCIETY, Hotel Stevens, Chicago, Ill.

Chemical
ECONOMICS and MARKETS

PRODUCTION OF CHEMICALS HELD STEADY RATE THROUGHOUT LAST MONTH

SOME improvement was reported in the movement of chemicals last month and this was reflected in some cases in an increase in production and in others by a lowering of stocks. In general however there was no material change in the rate of manufacturing operations. Greater activity in financial circles and the promise of large government expenditures have had the effect of bringing about a more cheerful attitude generally and this psychological development represents the greater part of the month's improvement although the closing days of June brought material gains in inquiries for different commodities. Deliveries of chemicals are not expected to widen in the next six weeks but confidence in improved business from September forward seems to have been generally restored. In addition to government buying, underlying conditions have turned for the better as a result of reducing inventories on the part of both producers and consumers. The trend toward higher prices also has been a factor in stimulating consumer inquiries and some change has been noted in policy of buying only for current needs in favor of covering for two or three months ahead.

In contrast to current reports of an anticipated rise in business for the third quarter of this year, comes the report from Shipping Conference Boards with an estimate that carloadings for the quarter will run 19.6 per cent below the actual loadings for the corresponding quarter of last year. Grains and dairy products are the only commodities which are expected to exceed the shipments of last year. Chemicals and explosives are expected to fall below last year's shipments by 12.6 per cent.

Current reports of considerable interest in fertilizer materials are encouraging in view of the fact that superphosphate production in May was somewhat larger than in April, in contrast to a seasonal decline which usually takes place between the two months. The increase over April was entirely in the Northern Area, with a slight decline reported by producers in the South. As compared with May of last year, there was a decline in output of 18 per cent, according to reports by acidulators to The National Fertilizer Association. Production in each month this year has been below the corresponding month of 1937. In the first 11 months of the current fiscal year, from July through May, production of reporting acidulators totaled 3,225,000 tons, a decline of 4 per cent from the same period of last year. Production in the last half of 1937 was relatively large.

Shipments of silk to domestic mills in June are estimated at 31,492 bales and with extensive buying recently in the cotton goods market, there is reason to hope for a more active season in textile manufacture. Reference to the accompanying table will show that for the first five months of this year, operations at textile plants were far below those which obtained in five-month period of 1937. In fact the industry statistics available to date, offer tangible evidence of the sharp drop in general business with varying degrees of decline for the separate industries.

In the glass trade, containers have made the best showing but in some cases container output in May was larger than the amount shipped. Flat glass, on the other hand, has moved in excess of the low rate of production and has improved its position statistically. Glassware production has taken on new life in the last two weeks with workers recalled to some of the plants which had been operating with a small force.

Manufacturers' sales during May, 1938, declined 28 per cent from last May according to reports from almost 1,100 manufacturers cooperating in the monthly joint study of the National Association of Credit Men and the Bureau of Foreign and Domestic Commerce. This decrease is only slightly less than the April drop of 29 per cent shown in last month's report.

Total net sales of manufacturers during May decreased 5 per cent from April, 1938, without adjustment for seasonal variation. This compares with a decrease of 3 per cent from April to May in 1937.

Every major industry group for which sales data are shown registered a decrease in sales during May, 1938, as compared with May of last year. The smallest decline was registered by the printing, publishing and allied industries group, whose sales were down 9½ per cent on this comparison. Other decreases ranged down to the drop of 56½ per cent recorded by the iron and steel products group.

Only 48 firms in the chemical and allied group contributed to this monthly survey and their combined reports indicate a drop of 21.1 per cent in sales for May as compared with those for May, 1937. Sales in May, 1938, also were reported at a decline of 3.3 per cent from those for the preceding month.

Eighteen producers of paint and varnish sent in reports which would place sales in that industry for May as 5.9 per cent below those for May, 1937, but 11.3 per cent above those for April, 1938.

Consumption of crude rubber by American manufacturers decreased 44.1 per cent during May, as compared with the same 1937 month, a report by the Rubber Manufacturers Association discloses. That authority estimates that the total used amounted to 28,947 long tons. The consumption in April amounted to 27,984, May showing a gain of 3.4 per cent. Consumption in May, 1937, amounted to 51,795 tons.

Consumption of reclaimed rubber showed an increase during May. The total was 8,009 tons, compared with 7,480 tons in April. Production aggregated 6,866 tons, against 6,399 tons, and stocks on May 31 totaled 22,275 tons, against 23,339 tons on hand at the end of May last year.

Production and Consumption Data for Chemical-Consuming Industries

Production	May 1938	May 1937	Jan.-May 1938	Jan.-May 1937	Per cent of decline for 1938
Alcohol, ethyl, 1000 pr. gal	14,226	16,939	77,826	89,913	13.4
Alcohol denatured, 1000 wi. gal	6,092	7,438	29,563	33,371	11.4
Benzol, 1000 gal	4,905	10,448	28,018	51,404	45.5
By product coke, 1000 tons	2,283	4,479	12,650	21,671	42.8
Glass containers, 1000 gr	3,837	4,844	17,241	21,504	19.8
Plate glass, 1000 sq. ft	3,866	19,271	19,271	87,185	77.9
Nitrocellulose plastics, 1000 lb	668	1,627	3,434	8,804	61.0
Cellulose acetate plastics, 1000 lb	258	1,170	1,357	6,325	78.5
Rubber reclaimed, tons	6,866	15,793	33,817	74,456	54.6
Rosin, wood, bbl	44,468	62,399	236,356	303,776	22.2
Turpentine, wood, bbl	6,944	9,637	36,636	48,010	23.7
Consumption					
Cotton, 1000 bales	426	670	2,213	3,510	37.0
Silk, bales	28,687	35,278	157,927	198,455	20.4
Wool, 1000 lb	15,980	32,969	79,125	184,027	57.0
Explosives, 1000 lb	24,904	31,972	123,651	172,847	28.4
Rubber, crude, tons	28,947	51,733	140,515	258,694	45.7

Production and Consumption Trends

COTTON CONSUMED

BYPRODUCT COKE PRODUCED

RUBBER RECLAIMED

PETROLEUM REFINED

GLASS CONTAINERS

METHANOL CRUDE

EXPLOSIVES

SULPHURIC ACID CONSUMED IN FERTILIZER

METHANOL SYNTHETIC

PYROXYLIN SPREAD

ALCOHOL DENATURED

CRUDE RUBBER CONSUMED

CELLULOSE PLASTIC PRODUCTS

PLATE GLASS

PAINT, VARNISH AND LACQUER SALES

WOOD PULP

LEATHER STOCKS FINISHED AND IN PROCESS

CHEMICAL STOCKS

FOREIGN TRADE IN CHEMICALS AND ALLIED PRODUCTS

Excess of exports over imports

Exports

Imports

NUMEROUS PRICE CHANGES MARKED TRADING IN CHEMICAL PRODUCTS

DEVELOPMENTS in the market for chemicals and related products were more interesting last month. In the first place there was a departure from the routine buying which has predominated and the larger quantities of some commodities taken by consumers indicated a trend toward covering more than current requirements. In the case of pure ethyl alcohol, borax and boric acid, this action was attributed to the desire of buyers to take on supplies prior to July 1 on which day, higher prices had been announced as to be become effective. Tire manufacturers were reported to have ordered out larger amounts of carbon gas black and this was regarded as indicative of increased operations at tire plants. Linseed oil also was in better demand and sales in the early part of July ran counter to the seasonal trend. Copper sulphate and other agricultural chemicals were included in the list of those chemicals which might be termed moderately active. Alkalis also showed a moderate improvement in shipments although some of the large consuming trades continue to lag. The enlarged interest shown in such markets as metals, rubber, cotton goods, etc., was a factor contributing to the wide rise in optimistic sentiment but so far as chemicals are concerned it is held that the next two months do not offer hopes of trade expansion but prospects for fall business are more favorable as actual expenditures of government money can hardly fail to result in demands for raw materials which will extend into practically every line of production.

The price movement showed no general trend but resulted largely from influences affecting the individual products. In the early part of the period values for metals were depressed with consumer interest lacking and reserve stocks large. Later on buyers came into the market and producers found it possible to obtain better prices for their offerings. As a result of the early condition, sales schedules for tin salts, lead carbonate, and lead oxides were revised downwards. When the metal markets turned stronger, quotations for tin salts and lead oxides again moved up and basic carbonate and basic sulphate of lead later on were advanced in price. Lithopone likewise was offered at a lower figure and while reduced production costs may have contributed it is probable that this action was at least partially the competition which has been given by other pigments.

While price changes for chemicals were in both directions, the course of values for vegetable oils and fats was entirely upward and a sharp advance was registered in the weighted index number. Disappearance of refined cottonseed oil has held up remarkably well and offerings of crude oil were more restricted and under this leadership, quotations for other vegetable oils were higher. Uncertainty regarding future shipments of wood oil from Chinese ports was a factor in raising asking prices of importers. Linseed oil, although finding a wider market, did not advance with the other oils.

Domestic production of synthetic methanol while showing a drop in May from that for the corresponding month of last year, still stands out as one of the chemicals which has surpassed last year's record to date. Production in May was reported at 1,860,400 gal. and the total for the first five months of this year is 11,367,400 gal. in contrast with 10,249,256 for the first five months of last year.

Crude methanol has not kept pace with synthetic product, the output for May having been 330,875 gal. with 1,945,616 gal. for the five-month period which compares with 2,627,105 gal. for Jan.-May period of 1937.

Special construction for experimental service of fusion-welded tank cars of stainless (chrome nickel) steel for hauling butyraldehyde has been granted by I.C.C. This authorization recognizes the proposed new specification for tank car 103 W, an alloy steel car of welded construction which will provide for handling numerous chemicals difficult to carry without contamination or leakage in rivetted cars or cars of non-alloy construction.

The Secretary of War is authorized to place educational orders for special munitions in order to acquaint manufacturers with the methods of production which will have to be met in war time. Purchases without competitive bidding are thus permitted on moderate quantities of goods not commonly made in peace time.

Both T.V.A. and the power sales manager for the Bonneville Dam announced during June their allocation of costs and price schedules for power. Thus those wishing to buy energy from these Government dams now know much more about costs and prices, can negotiate in a business-like manner.

Reform-minded officials continue to press on a new philosophy of price fixing. They argue that prices should be drastically cut in order to stimulate buying. Apparently this argument was largely influential in forcing the cut in steel prices the end of June. Incidentally the Government is taking steps to buy now, partly to stimulate business and partly to take advantage of low market prices.

Among foreign developments of interest is a report to the Department of Commerce which states that rivalry between the Japanese Mitsui and Mitsubishi interests over the right to manage the Yungli Chemical Company's ammonium sulphate plant at Pukow, across the Yangtze River from Nanking, China, is reported by the Nikkan Kogyo. The plant is one of the largest in China and has an annual capacity of 50,000 metric tons of ammonium sulphate.

The Toyo High Pressure Industry Company, directly controlled by Mitsui, has completed preparations for taking over the Pukow factory. However, the Yungli Chemical's soda plant at Tangku has already been confiscated by the China Development Company, which transferred it to the Asahi Glass Company, a Mitsubishi subsidiary.

Another Mitsubishi concern, the Japan Chemical Industry Company, is also trying to secure the right to manage the Pukow plant. Seeking to prevent this step, Mitsui officials have taken steps to obtain control. The report adds, however, that officials in Nanking do not welcome a monopoly by any one company and have consequently not decided to whom the Pukow plant is to be consigned.

CHEM. & MET.

Weighted Index of

CHEMICAL PRICES

Base = 100 for 1935

This month	99.68
Last month	99.79
July, 1937	102.04
July, 1936	98.70

An irregular price movement prevailed with advances reported for borax, boric acid, copper sulphate, tartaric acid and cream of tartar. Declines were effective for sulphate of ammonia and lithopone. The weighted index was lower.

CHEM. & MET.

Weighted Index of Prices for

OILS AND FATS

Base = 100 for 1935

This month	79.68
Last month	74.98
July, 1937	102.53
July, 1936	86.00

Price recoveries were almost general throughout the market for oils and animal fats. This held true for both domestic and imported products. Linseed oil was in better demand but held an unchanged price level.

INDUSTRIAL CHEMICALS

	Current Price	Last Month	Last Year
Acetone, drums, lb.	$0.05½–$0.06½	$0.05½–$0.06½	$0.06 –$0.07
Acid, acetic, 28%, bbl., cwt.	2.23 – 2.48	2.23 – 2.48	2.53 – 2.78
Glacial 99%, drums.	8.43 – 8.68	8.43 – 8.68	8.70 – 8.95
U. S. P. reagent.	10.25 –10.50	10.25 –10.50	10.75 –11.00
Boric, bbl., ton.	106.00–111.00	105.00–115.00	105.00–115.00
Citric, kegs, lb.	.23½ – .25	.24 – .27	.25 – .28
Formic, bbl., ton.	.10½ – .11	.10½ – .11	.11 – .11½
Gallic, tech., bbl., lb.	.70 – .75	.75 – .78	.60 – .65
Hydrofluoric 30% carb., lb.	.07 – .07½	.07 – .07½	.07 – .07½
Lactic, 44%, tech., light, bbl., lb.	.06¼ – .06½	.06¼ – .06½	.6¼ – .6½
Muriatic, 18°, tanks, cwt.	1.05 –.....	1.05 –.....	1.05 –.....
Nitric, 36°, carboys, lb.	.05 – .05½	.05 – .05½	.05 – .05½
Oleum, tanks, wks., ton.	18.50 –20.00	18.50 –.....	18.50 –20.00
Oxalic, crystals, bbl., lb.	.10½ – .12	.10½ – .12	.10½ – .12
Phosphoric, tech., c'bys., lb.	.09 – .10	.09 – .10	.09 – .10
Sulphuric, 60°, tanks, ton.	13.00 –.....	13.00 –.....	13.00 –.....
Sulphuric, 66°, tanks, ton.	16.50 –.....	16.50 –.....	16.50 –.....
Tannic, tech., bbl., lb.	.40 – .45	.40 – .45	.40 – .45
Tartaric, powd., bbl., lb.	.27½ –.....	.26½ –.....	.24½ –.....
Tungstic, bbl., lb.	2.75 –.....	2.75 –.....	2.75 –.....
Alcohol, Amyl.	..... –.....	..... –.....	..... –.....
From Pentane, tanks, lb.	.123 –.....	.123 –.....	.123 –.....
Alcohol, Butyl, tanks, lb.	.08½ –.....	.08½ –.....	.08½ –.....
Alcohol, Ethyl, 190p'f., bbl., gal.	4.58½ –.....	4.11 –.....	4.14 –.....
Denatured, 190 proof.			
No. 1 special, dr., gal wks.	.31 –.....	.31 –.....	.34 –.....
Alum, ammonia, lump, bbl., lb.	.03½ – .04	.03½ – .04	.03 – .04
Potash, lump, bbl., lb.	.03½ – .04	.03½ – .04	.03 – .04
Aluminum sulphate, com bags cwt.	1.15 – 1.40	1.15 – 1.40	1.35 – 1.50
Iron free, bg., cwt.	1.30 – 1.55	1.30 – 1.55	2.00 – 2.25
Aqua ammonia, 26°, drums, lb.	.02½ – .03	.02½ – .03	.02½ – .03
tanks, lb.	.02½ – .02½	.02½ – .02½	.02½ – .02½
Ammonia, anhydrous, cyl., lb.	.15½ –.....	.15½ –.....	.15½ – .16
tanks, lb.	.04½ –.....	.04½ –.....	.04½ –.....
Ammonium carbonate, powd tech., casks, lb.	.08 – .12	.08 – .12	.08 – .12
Sulphate, wks., cwt.	1.325 –.....	1.475 –.....	1.425 –.....
Amylacetate tech., tanks, lb.	.11 – .12	.11 – .12	.11 – .11½
Antimony Oxide, bbl., lb.	.11½ – .12	.12 – .13	.16 – .16½
Arsenic, white, powd., bbl., lb.	.03 – .03½	.03 – .03½	.03 – .03½
Red, powd., kegs, lb.	.15½ – .16	.15½ – .16	.15½ – .16
Barium carbonate, bbl., ton.	52.50 –57.50	52.50 –57.50	52.50 –57.50
Chloride, bbl., ton.	79.00 –81.00	79.00 –81.00	79.00 –81.00
Nitrate, cask, lb.	.07 – .08	.07 – .08	.07 – .08
Blanc fixe, dry, bbl., lb.	.03½ – .04	.03½ – .04	.03½ – .04
Bleaching powder, f. o b., wks., drums, cwt.	2.00 – 2.10	2.00 – 2.10	2.00 – 2.10
Borax, gran., bags, ton.	48.00 –51.00	46.00 –51.00	46.00 –51.00
Bromine, cs., lb.	.30 – .32	.30 – .32	.36 – .38
Calcium acetate, bags.	1.65 –.....	1.65 –.....	2.25 –.....
Arsenate, dr., lb.	.06½ – .07	.06½ – .07	.06½ – .07
Carbide drums, lb.	.05 – .06	.05 – .06	.05 – .06
Chloride, fused, dr., del., ton.	21.50 –24.50	21.50 –24.50	20.00 –33.00
flake, dr., del., ton.	23.00 –25.00	23.00 –25.00	22.00 –35.00
Phosphate, bbl., lb.	.07½ – .08	.07½ – .08	.07½ – .08
Carbon bisulphide, drums, lb.	.05 – .06	.05 – .06	.05½ – .06
Tetrachloride drums, lb.	.05½ – .06	.05½ – .06	.05½ – .06
Chlorine, liquid, tanks, wks., lb.	2.15 –.....	2.15 –.....	2.15 –.....
Cylinders	.05½ – .06	.05½ – .06	.05½ – .06
Cobalt oxide, cans, lb.	1.67 – 1.70	1.67 – 1.70	1.67 – 1.70
Copperas, bgs., f.o.b., wks., ton.	15.00 –16.00	15.00 –16.00	15.00 –16.00
Copper carbonate, bbl., lb.	.09 – .16½	.09 – .16½	.10½ – .19½
Sulphate, bbl., cwt.	4.15 – 4.40	4.00 – 4.25	5.15 – 5.40
Cream of tartar, bbl., lb.	.21½ – .22	.21½ – .22	.18½ – .19
Diethylene glycol, dr., lb.	.22 – .23	.22 – .23	.22 – .23
Epsom salt, dom., tech., bbl., cwt.	1.80 – 2.00	1.80 – 2.00	1.80 – 2.00
Ethyl acetate, drums, lb.	.06½ –.....	.06½ –.....	.07 –.....
Formaldehyde, 40%, bbl., lb.	.05½ – .06½	.05½ – .06½	.05½ – .6½
Furfural, dr., lb.	.10 – .17½	.10 – .17½	.10 – .17½
Fusel oil, ref. drums, lb.	.16 – .18	.16 – .18	.16 – .18
Glaubers salt, bags, cwt.	.95 – 1.00	.95 – 1.00	.85 – 1.00
Glycerine, c.p., drums, extra, lb.	.16½ –.....	.15½ –.....	.23½ –.....
Lead:			
White, basic carbonate, dry casks, lb.	.06½ –.....	.06½ –.....	.07½ –.....
White, basic sulphate, sck., lb.	.05½ –.....	.05½ –.....	.07½ –.....
Red, dry, sck, lb.	.07½ –.....	.06½ –.....	.08½ –.....
Lead acetate, white crys., bbl., lb.	.10 – .11	.10 – .11	.13½ – .14
Lead arsenate, powd., bbl., lb.	.12½ – .13	.13 – .13½	.11½ – .12
Lime, chem., bulk, ton.	8.50 –.....	8.50 –.....	8.50 –.....
Litharge, pwd., csk., lb.	.06½ –.....	.05½ –.....	.07½ –.....
Lithophone, bags, lb.	.04½ – .04½	.04½ – .04½	.04½ – .05
Magnesium carb., tech., bags, lb.	.06 – .06½	.06 – .06½	.06 – .06½

The accompanying prices refer to round lots in the New York market. Where it is the trade custom to sell f.o.b. works, quotations are given on that basis and are so designated. Prices are corrected to July 13
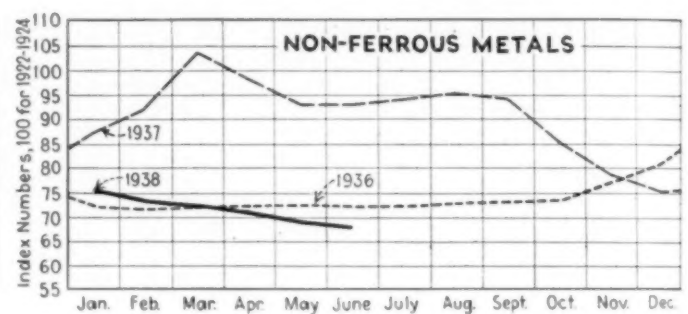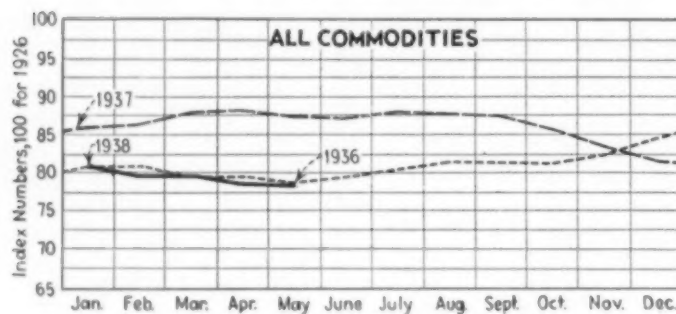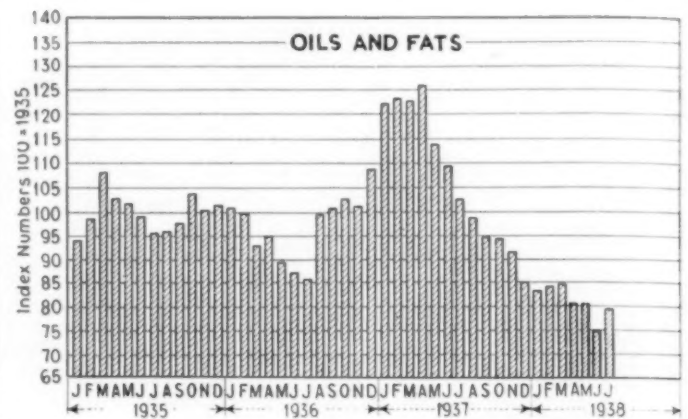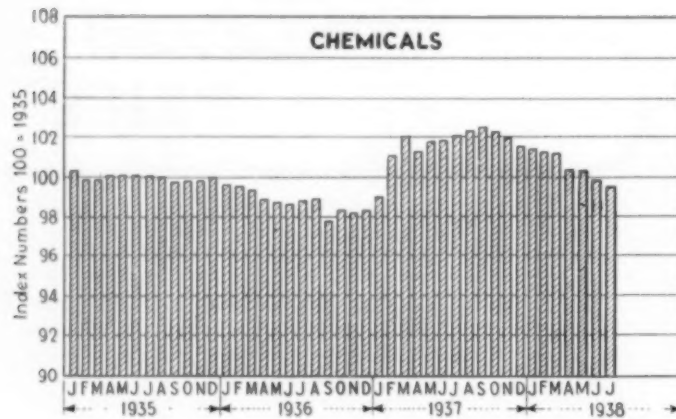

	Current Price	Last Month	Last Year
Methanol, 95%, tanks, gal.	.31 –.....	.31 –.....	.31 –.....
97%, tanks, gal.	.32 –.....	.32 –.....	.32 –.....
Synthetic, tanks, gal.	.33 –.....	.33 –.....	.33 –.....
Nickel salt, double, bbl., lb.	.13 – .13½	.13 – .13½	.13 – .13½
Orange mineral, csk., lb.	.10½ –.....	.09½ –.....	.11½ –.....
Phosphorus, red, cases, lb.	.40 – .42	.40 – .42	.40 – .42
Yellow, cases, lb.	.24 – .30	.24 – .30	.24 – .30
Potassium bichromate, casks, lb.	.08½ – .09	.08½ – .09	.08½ – .09
Carbonate, 80–85%, calc. csk., lb.	.05½ – .06	.05½ – .06	–.06½ .07
Chlorate, powd., lb.	.09½ –.....	.09½ –.....	.09½ –.....
Hydroxide (c'stic potash) dr., lb.	.07 – .07½	.07 – .07½	.07 – .07½
Muriate, 80% bgs., unit.	.53½ –.....	.53½ –.....	.53½ –.....
Nitrate, bbl. lb.	.05½ – .06	.05½ – .06	.05½ – .06
Permanganate, drums, lb.	.18½ – .19	.18½ – .19	.18½ – .19
Prussiate, yellow, casks, lb.	.15 – .16	.15 – .16	.15 – .16
Sal ammoniac, white, casks, lb.	.05 – .05½	.05 – .05½	.05 – .05½
Salsoda, bbl., cwt.	1.00 – 1.05	1.00 – 1.05	1.00 – 1.05
Salt cake, bulk, ton.	13.00 –15.00	13.00 –15.00	13.00 –15.00
Soda ash, light, 58%, bags, contract, cwt.	1.23 –.....	1.23 –.....	1.23 –.....
Dense, bags, cwt.	1.25 –.....	1.25 –.....	1.25 –.....
Soda, caustic, 76%, solid, drums, contract, cwt.	2.60 – 3.00	2.60 – 3.00	2.60 – 3.00
Acetate, works, bbl., lb.	.04 – .05	.04 – .05	.04½ – .05
Bicarbonate, bbl., cwt.	1.75 – 2.00	1.75 – 2.00	1.75 – 2.00
Bichromate, casks, lb.	.06½ – .07	.06½ – .07	.06½ – .07
Bisulphate, bulk, ton.	15.00 –16.00	15.00 –16.00	15.00 –16.00
Bisulphite, bbl., lb.	.03½ – .04	.03½ – .04	.03½ – .04
Chlorate, kegs, lb.	.06½ – .06½	.06½ – .06½	.06½ – .06½
Chloride, tech., ton.	12.00 –14.75	12.00 –14.75	12.00 –14.75
Cyanide, cases, dom., lb.	.14 – .15	.14 – .15	.16½ – .17
Fluoride, bbl., lb.	.07½ – .08	.07½ – .08	.07½ – .08
Hyposulphite, bbl., cwt.	2.40 – 2.50	2.40 – 2.50	2.40 – 2.50
Metasilicate, bbl., cwt.	2.20 – 3.20	2.20 – 3.20	2.15 – 3.13
Nitrate, bags, cwt.	1.45 –.....	1.45 –.....	1.425 –.....
Nitrite, casks, lb.	.06½ – .07	.06½ – .07	.07 – .08
Phosphate, dibasic, bags, lb.	1.85 –.....	1.85 –.....	.022– .024
Prussiate, yel. drums, lb.	.09½ – .10	.09½ – .10	.10 – .11
Silicate (40° dr.) wks., cwt.	.80 – .85	.80 – .85	.80 – .85
Sulphide, fused, 60–62%, dr., lb.	.02½ – .03	.02½ – .03	.02½ – .03
Sulphite, cyrs., bbl., lb.	.02½ – .02½	.02½ – .02½	.02½ – .02½
Sulphur, crude at mine, bulk, ton.	18.00 –.....	18.00 –.....	18.00 –.....
Chloride, dr., lb.	.03 – .04	.03 – .04	.03½ – .04
Dioxide, cyl., lb.	.07 – .08	.07 – .08	.07 – .07½
Flour, bag, cwt.	1.60 – 3.00	1.60 – 3.00	1.60 – 3.00
Tin Oxide, bbl., lb.	.44 –.....	.44 –.....	.58 –.....
Crystals, bbl., lb.	.35 –.....	.33 –.....	.40½ –.....
Zinc chloride, gran., bbl., lb.	.05 – .06	.05 – .06	.05 – .06
Carbonate, bbl., lb.	.14 – .15	.14 – .15	.09 – .11
Cyanide, dr., lb.	.33 – .35	.33 – .35	.36 – .38
Dust, bbl., lb.	.06½ –.....	.06½ –.....	.0865–.....
Zinc oxide, lead free, bag., lb.	.06½ –.....	.06½ –.....	.06½ –.....
5% lead sulphate, bags, lb.	.06½ –.....	.06½ –.....	.06½ –.....
Sulphate, bbl., cwt.	3.15 – 3.60	3.15 – 3.60	3.15 – 3.60

OILS AND FATS

	Current Price	Last Month	Last Year
Castor oil, No. 3, bbl., lb.	$0.09½–$0.10	$0.09½–$0.10	$0.10½–$0.11
Chinawood oil, bbl., lb.	.12½ –.....	.10½ –.....	.12½ –.....
Coconut oil, Ceylon, tanks, N. Y. lb.	.03¾ –.....	.03½ –.....	.05½ –.....
Corn oil crude, tanks (f.o.b. mill), lb.	.07½ –.....	.07 –.....	.08 –.....
Cottonseed oil, crude (f.o.b. mill), tanks, lb.	.07 –.....	.06½ –.....	.08 –.....
Linseed oil, raw car lots, bbl., lb.	.086 –.....	.086 –.....	.11 –.....
Palm, casks, lb.	.04 –.....	.03½ –.....	.05½ –.....
Peanut oil, crude, tanks (mill), lb.	.07½ –.....	.06½ –.....	.08 –.....
Rapeseed oil, refined, bbl., gal.	.75 –.....	.78 –.....	.95 –.....
Soya bean, tank, lb.	.06 –.....	.05½ –.....	.07½ –.....
Sulphur (olive foots), bbl., lb.	.07½ –.....	.07½ –.....	.11½ –.....
Cod, Newfoundland, bbl., gal.	.50 –.....	.50 –.....	.52 –.....
Menhaden, light pressed, bbl., lb.	.069 –.....	.07½ –.....	.09 –.....
Crude, tanks (f.o.b. factory), gal.	.27 –.....	.35 –.....	.40 –.....
Grease, yellow, loose, lb.	.04½ –.....	.04½ –.....	.07½ –.....
Oleo stearine, lb.	.07½ –.....	.07½ –.....	.09½ –.....
Oleo oil, No. 1.	.09 –.....	.08½ –.....	.13 –.....
Red oil, distilled, d.p. bbl., lb.	.08½ –.....	.08½ –.....	.11½ –.....
Tallow extra, loose, lb.	.05½ –.....	.04½ –.....	.08½ –.....

Chem. & Met.'s Weighted Price Indexes

CHEMICALS — Index Numbers 100 = 1935
J F M A M J J A S O N D — 1935 · 1936 · 1937 · 1938

OILS AND FATS — Index Numbers 100 = 1935
J F M A M J J A S O N D — 1935 · 1936 · 1937 · 1938

ALL COMMODITIES — Index Numbers, 100 for 1926
1937, 1938, 1936
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

NON-FERROUS METALS — Index Numbers, 100 for 1922-1924
1937, 1938, 1936
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

COAL-TAR PRODUCTS

	Current Price	Last Month	Last Year
Alpha-napthol, crude bbl., lb	$0 52 –$0 55	$0 52 –$0 55	$0 52 –$0 55
Alpha-naphthylamine, bbl., lb	.32 – .34	.32 – .34	.32 – .34
Aniline oil, drums, extra, lb	.15 – .16	.15 – .16	.15 – .16
Aniline salts, bbl., lb	.22 – .24	.22 – .24	.24 – .25
Benzaldehyde, U.S.P., dr., lb	.85 – .95	.85 – .95	.85 – .95
Bensidine base, bbl., lb	.70 – .75	.70 – .75	.70 – .75
Benzoic acid, U.S.P., kgs., lb	.54 – .56	.54 – .56	.52 – .54
Benzyl chloride, tech., dr., lb	.25 – .27	.25 – .27	.25 – .27
Benzol, 90%, tanks, works, gal	.16 – .18	.16 – .18	.16 – .18
Beta-napthol, tech., drums, lb	.23 – .24	.23 – .24	.23 – .24
Cresol, U.S.P., dr., lb	.10½ – .11	.12 – .13	.12 – .13
Cresylic acid, dr., wks., gal	.78 – .80	.87 – .89	.92 – 1.00
Diethylaniline, dr., lb	.40 – .45	.40 – .45	.50 – .55
Dinitrophenol, bbl., lb	.23 – .25	.23 – .25	.23 – .25
Dinitrotoluen, bbl., lb	.15 – .16	.15 – .16	.15 – .16
Dip oil, 15%, dr., gal	.23 – .25	.23 – .25	.23 – .25
Diphenylamine, bbl., lb	.32 – .36	.32 – .36	.32 – .36
H-acid, bbl., lb	.50 – .55	.50 – .55	.50 – .55
Naphthalene, flake, bbl., lb	.06½ – .07	.06½ – .07	.07½ – .07½
Nitrobenzene, dr., lb	.08 – .09	.08 – .09	.08 – .09
Para-nitraniline, bbl., lb	.50 – .52	.50 – .52	.45 – .47
Phenol, U.S.P., drums, lb	.14½	.14½	.13½ – .14
Picric acid, bbl., lb	.35 – .40	.35 – .40	.35 – .40
Pyridine, dr., gal	1.55 – 1.60	1.55 – 1.60	1.55 – 1.60
Resorcinal, tech., kegs, lb	.75 – .80	.75 – .80	.75 – .80
Salicylic acid, tech., bbl., lb	.33 – .40	.33 – .40	.34 – .40
Solvent naptha, w.w., tanks, gal	.26 –	.26 –	.30 –
Tolidine, bbl., lb	.88 – .90	.88 – .90	.88 – .90
Toluene, tanks, works, gal	.26 –	.26 –	.35 –
Xylene, com, tanks, gal	.26 –	.26 –	.35 –

MISCELLANEOUS

	Current Price	Last Month	Last Year
Barytes, grd., white, bbl., ton	$22 00–$25 00	$22 00–$25 00	$22 00–$25 00
Casein, tech., bbl., lb	.08 – .10½	.07½ – .12½	.13 – .14
China clay, dom., f.o.b. mine, ton	8.00 – 20.00	8.00 – 20.00	8.00 – 20.00
Dry colors			
Carbon gas, black (wks.), lb	.02½ – 30	.02½ – 30	.04 – 30
Prussian blue, bbl., lb	.36 – 37	.36 – 37	.37 – 38
Ultramarine blue, bbl. lb	.10 – 26	.10 – 26	.10 – 26
Chrome green, bbl., lb	.21 – 30	.21 – 30	.26 – 27
Carmine red, tins, lb	4.00 – 4.40	4.00 – 4.40	4.00 – 4.40
Para toner, lb	.75 – 80	.75 – 80	.75 – 80
Vermilion, English, bbl., lb	1.55 – 1.60	1.55 – 1.60	1.80 – 1.90
Chrome yellow, C. P., bbl., lb	.14½ – 15½	.14½ – 15½	.13 – .14
Feldspar, No. 1 (f.o.b. N.C.), ton	6.50 – 7.50	6.50 – 7.50	6.50 – 7.50
Graphite, Ceylon, lump, bbl., lb	.06 – .06½	.06 – .06½	.06 – .06½
Gum copal Congo, bags, lb	.06 – 30	.06 – 30	.08 – 30
Manila, bags, lb	.07 – .14	.07 – .14	.09 – .14
Damar, Batavia, cases, lb	.16 – .24	.16 – .24	.15½ – .16
Kauri cases, lb	.17½ – .60	.17½ – .60	.19 – 25
Kieselguhr (f.o.b. N. Y.), ton	50.00 –55.00	50.00 –55.00	50.00 –55.00
Magnesite, calc, ton	50.00 –	50.00 –	50.00 –
Pumice stone, lump, bbl., lb	.05 – .07	.05 – .08	.05 – 07
Imported, casks, lb	.03 – .04	.03 – .04	.03 – 04
Rosin, H., bbl	6.10 –	5.65 –	9.35 –
Turpentine, gal	.29 –	28½ –	.39½ –
Shellac, orange, fine, bags, lb	.20 –	.20 –	.23 –
Bleached, bonedry, bags, lb	.18 –	.17 –	.17½ –
T. N. Bags, lb	.11 –	.11 –	.12½ –
Soapstone (f.o.b. Vt.), bags, ton	10 00 –12.00	10.00 –12.00	10.00 –12 00
Talc, 200 mesh (f.o.b. Vt.), ton	8 00 – 8.50	8.00 – 8.50	8.00 – 8.50
300 mesh (f.o.b. Ga.), ton	7 50 –10.00	7.50 –10.00	7.50 –11.00
225 mesh (f.o.b. N. Y.), ton	13.75 –	13.75 –	13.75 –

INDUSTRIAL NOTES

INTERNATIONAL NICKEL CO., New York, Development and Research Division, has opened a new field office in the Grant Bldg., Pittsburgh, with H. V. Beasley in charge.

COMMERCIAL SOLVENTS CORP., New York, has transferred its advertising and sales promotion headquarters, except for anti-freeze products, to Terre Haute, Ind., under the direction of George O. Lines.

WESTINGHOUSE ELECTRIC & MFG. CO., East Pittsburgh, Pa., has formed an agency sales department. F. R. Kohnstamm is in charge with Cleveland as headquarters.

STEVENS METAL SPRAYING, INC. Oakland, Calif., has moved its plant and offices to 2527 Magnolia St.

AMERICAN ENGINEERING CO., Philadelphia has appointed Robert T. Forbes, 201 Devonshire St., as New England representative.

H. SEYMOUR COLTON, consulting chemical engineer, Cleveland, has moved his offices to the Standard Bldg.

GENERAL REFRACTORIES CO., Philadelphia, has appointed the following as distributors: Slip Not Belting Co., Kingsport, Tenn.; Fleck Co., Camden, N. J.; New England Brick Co., Boston, Mass.; and Lusco Brick & Stone Co., Kansas City, Kans.

CONNECTICUT BLOWER CO., Hartford, Conn., has appointed Julius Lamparzyk, Cleveland, sales engineer for Ohio and Arthur Polston, Louisville, sales engineer for Kentucky.

F. J. STOKES, MACHINE CO., Philadelphia, has become sole sale agents for standard plastic molding presser manufactured by Standard Machinery Co., Mystic, Conn.

REPUBLIC STEEL CORP., Cleveland, has appointed Union Hardware and Metal Co., Los Angeles, as distributor for Enduro stainless steel.

New CONSTRUCTION

PROPOSED WORK

Alcohol Factory, Etc.—Methyl Products, Ltd., c/o Shawinigan Chemicals, Ltd., 107 Craig St., W., Montreal, Que., Can., is having plans prepared for a factory for the production of synthetic methyl alcohol and allied products. Estimated cost $150,000.

Cement Plant—Municipality, Winnipeg, Man., Can., contemplates the construction of a municipal cement plant. Estimated cost $500,000.

Chemical Factory—Bird, Archer Co., Ltd., 485 McGill St., Montreal, Que., Can., is having plans prepared for an addition to its chemical plant at Cobourg, Ont., Can. Estimated cost $40,000.

Distillery—C. K. Lukis, M. D. and Associates, McAllen, Tex., plan to construct a 1 and 2 story distillery for the production of cologne, antiseptics, perfume and blends for wines and liquors. Estimated cost $60,000.

Gas Plant—Iowa Electric Light & Power Co., Boone, Ia., plans improvements to Boone gas plant which serves Ames, Nevada, Boone and Iowa State College. Estimated cost $35,000.

Glass Factory—Dominion Glass Co., Ltd., 1111 Beaver Hall Hill, Montreal, Que., Can., is having private plans prepared for the construction of an additional unit at its factory at Wallaceburg, Ont. Estimated cost $50,000.

Oil Mill—City, c/o E. V. Spence, Mgr., Big Spring, Tex., contemplates the construction of a 1 story fireproof oil mill for the manufacture of cottonseed by-products, etc. Estimated cost $100,000.

Oil Refinery—Lions Oils, Ltd., 7 Manchester St., Calgary, Alta., Can., is having plans prepared for the construction of an oil refinery to have a daily capacity of 1,000 bbl. Estimated cost $400,000.

Oil Refinery—Pembina Oils, Ltd., Medicine Hat, Alta., Can., plans to construct an oil refinery here. Estimated cost $50,000.

Paper Mill—Valleyfield Coated Paper Mills, Ltd., St. Phillipe St., Valleyfield, Que., Can., is having plans prepared for the construction of a 1-story, brick and steel mill. Estimated cost $125,000.

Roofing Plant—Dixie Asphalt Co., c/o Robert M. Nelson, 5021 Eighth Ave., Brooklyn, N. Y., plans to construct a roofing plant at Savannah, Ga. Estimated cost $250,000.

Oil Refinery—Producers Refining Co., Kansas City, Mo., and Shelby, Mont., will soon award the contract for the construction of an oil refinery at Shelby, Mont., to have a capacity of 3,000 bbl. Estimated cost $600,000.

Smokeless Fuel Plant—Midwest Smokeless Fuel Corp., c/o Robert S. Smith, Smith, Moore & Co., 509 Oliver St., St. Louis, Mo., contemplates the construction of a coal processing plant to consist of 20 carbonizing ovens and coal washer to have a capacity of 75,000 tons per year, near East St Louis and Belleville, Ill. Estimated cost $1,000,000.

Where Plants Are Being Built in Process Industries

	Current Projects		Cumulative 1938	
	Proposed Work	Contracts	Proposed Work	Contracts
New England	....	$50,000	$240,000	$879,000
Middle Atlantic	....	1,120,000	5,969,000	3,018,000
South	$ 290,000	....	20,470,000	9,252,000
Middle West	1,000,000	90,000	13,077,000	3,910,000
West of Mississippi	795,000	105,000	17,235,000	4,870,000
Far West	250,000	....	1,180,000	2,397,000
Canada	2,315,000	150,000	16,910,000	3,860,000
Total	$4,650,000	$1,515,000	$75,081,000	$28,186,000

Sulphate of Alumina Plant—American Cyanamid & Chemical Corp., 30 Rockefeller Plaza, New York, N. Y., plans to construct a plant for the manufacture of sulphate of alumina to be used in paper making. The plant will be located on the Terminal R. R., of the Alabama State Docks Commission near Mobile, Ala.

Ore Smelter—Chromium Mining & Smelting Co., Ltd., Canadian Bank of Commerce Bldg., Hamilton, Ont., Can., is having plans prepared for the construction of an ore smelter on the Tidewater at Montreal, Que. The Company plans to purchase new machinery. Estimated cost, $1,000,000.

Ore Mill—A. C. Murray and associates, 202 East Fifth St., Aberdeen, Wash., plan to construct a plant to reduce manganese ore and other minerals, at Neilton, Wash. Estimated cost $200,000.

Smelter—Columbia Rivers Smelter Co., c/o F. F. Barnes, East 408 Sprague St., Spokane, Wash., plans to construct a smelter to have a capacity of 250 tons of ore per day, at Northport, Wash. Estimated cost $50,000.

Equipment—George F. Gregory & Son, Petrolia, Ont., Can., plan extensive drilling operations for oil and gas on Cockburn Island and are interested in prices of equipment.

CONTRACTS AWARDED

Cataclyst Building—General Plastics, Inc., North Tonawanda, N. Y., has awarded the contract for the construction of a cataclyst building on Walck Rd., to George W. Morris Corp., 325 Jackson Bldg., Buffalo, N. Y. Estimated cost $500,000.

Distillery—Calvert Distilling Co., Relay, Md., has awarded the contract for the construction of a distillery to Hays & Nicoulin, 939 Franklin St., Louisville, Ky. Estimated cost $80,000.

Brass Mill—American Brass Co., 58 Liberty St., Ansonia, Conn., will construct a 1 story, 155x180 ft. brick and steel copper rolling mill. Work will be done by owner. Estimated cost $50,000.

Distillery—Meadville Distillery Co., T. Krantz in charge, Box 444, Meadville,

Pa., will construct a new distillery to include a warehouse. The Company will also install new equipment in its other buildings. Work will be done by day labor and separate contracts. F. F. Ballinger Co., Ambridge, Pa., Engr. Estimated cost $300,000.

Factory—Hall China Co., East Liverpool, O., has awarded the contract for the construction of a 1 story, 24,000 sq. ft. space, addition to its factory on Klondyke St., to provide additional manufacturing space for pottery and to include a warehouse, to D. F. Nellis & Sons Co., East Liverpool. Estimated cost $40,000. Work will be started immediately and is expected to be completed in 90 days.

Factory—International Nickel Co., 15 Oak St., Bayonne, N. J., has awarded the contract for three additions to its factory, 1 story, 25x50 ft., 55x145 ft. and 50x60 ft., to Deakman Wells Co., 921 Bergen Ave., Jersey City, N. J. Estimated cost $200,000.

Factory—Sterling China Co., Wellsville, O., manufacturer of hotel china, has awarded the contract for the construction of a 2 story addition to its factory on 12th St., Wellsville, to provide additional space for the slip house and larger quarters for the clay shop, to D. F. Nellis & Sons, Co., East Liverpool, O. Estimated cost $50,000.

Fractionating Plant—Hamman Exploration Co., c/o J. Hamman, Pres., Bay City, Tex., will construct a modern gasoline and refractionating plant to have a daily capacity of 22,000,000 cu. ft. of gas and approximately 200 bbl. water-white distillate. Work will be done by day labor and separate contracts. Estimated cost $105,000.

Paint Factory—Raker Paint Co., H. Raker, Pres., 850 Providence Rd., Scranton, Pa., has awarded separate contracts for the construction of a 1 story plant at 840 Providence Rd. Estimated cost including equipment $40,000.

Roofing Factory—London Roofing Products, J. W. Milner, Owner, 1266 Bridges St., London, Ont., Can., has awarded the contract for the construction of a 1 story, 50x150 ft. factory on Trafalger St., London, to W. C. Northey, 373 Wortley St., London. Special equipment will be installed for the manufacture of roofing products. Estimated cost $150,000.

WORLD CHEMICAL PRODUCTION MADE PROGRESS
LAST YEAR

EXPANSION of production facilities, the inauguration of new industries, stocking for emergencies, and governmental interest in chemical manufacture were outstanding features of world chemical developments in 1937, according to a world survey of the chemical and allied product industry made by the Commerce Department's Chemical Division.

The chemical industry of the world during 1937 continued the progress made in the preceding years; there was considerable improvement in the financial condition of the chemical industry which in many countries recorded the most prosperous year since 1929.

Strong nationalistic and rearmament programs encouraged the rapid progress of manufacture of chemical products, especially in European countries, notwithstanding that sometimes these new industries were uneconomic. The industry on a few occasions for short periods was hampered by interruption of raw material supplies by conditions existing in supplying countries, but at no time was the condition serious.

Foreign chemical trade in 1937 considerably exceeded preceding years and was the largest since 1929; the loss or reduction of purchases in certain regions was more than offset by increased purchases in other countries.

In South America, the chemical market was influenced less by these events than elsewhere, though competition from certain European countries was keener and the almost world-wide self-sufficiency movement was evident in the area.

Accentuated rearmament programs continued in almost all European countries and brought about increased production and demand for many chemical products. The peak at which iron and steel industries operated was reflected in increased output of co-products.

The continued civil war in Spain reduced chemical exports from European suppliers to that country and caused them to seek foreign outlets elsewhere, as well as to look for new sources of supply for certain raw materials formerly supplied by Spain. Despite conditions in Spain, however, that country exported 2,292,000 metric tons of pyrites last year against 1,985,000 tons in 1936. The withdrawal of Spanish potash from world markets was automatically taken care of by the International Potash Cartel.

Italy reentered world chemical markets with products which had been temporarily withdrawn during the Ethiopian campaign. An outstanding effect, so far as the United States is concerned, was the resumption of Italian sulphur shipments to markets which obtained their sulphur requirements from the United States during 1936.

In the Far East, the Sino-Japanese situation tended to disorganize trade in that region during the latter part of the year and resulted in much of Shanghai's normal business being rerouted through Hong Kong. Despite these conditions, however, China was able to export an all time record quantity of tung oil to world markets, particularly to the United States, its leading foreign market for this essential raw material.

No significant changes were reported in connection with the large international cartels, such as those controlling international movements of nitrogen, potash, chlorates, dyes, sodium sulphate, alkalis, calcium carbide, cyanides and certain fine chemicals.

World Commodity Data

World data on many chemical commodities are not available, but from time to time some statistical data are gathered by various unofficial organizations, and it has been the policy to publish such material in World Chemical Developments or in World Trade Notes on Chemicals and Allied Products. The following statistics have been taken from unofficial sources.

An estimate of 350,000 metric tons, annually, for 1935 and 1936 production of bleaching powder throughout the world was published in a European journal. The chief producing countries are Germany, Great Britain, Soviet Union, United States, and Japan. Other significant suppliers are Belgium, France, Spain, Italy, Czechoslovakia, and Sweden. World exports in 1936 were 60,000 to 70,000 tons, compared with 70,000 to 80,000 tons in 1929. About 90 per cent of the exports originate in Great Britain. Germany, Japan, Belgium, France, and the Soviet Union. Principal importers are Sweden, British India, China, Finland, Netherlands, and Norway.

A rise in the output of synthetic textile fiber has been the chief factor in the increased world production of carbon bisulphide, from 110,000 metric tons in 1929 to 260,000 in 1936. It is estimated that 90 per cent of the world production is accounted for by six countries—Germany, Japan, United States, Italy, United Kingdom, and France—and that 80 per cent of consumption is accounted for by industries producing fibers and other materials based on cellulose xanthate as an intermediate.

A German survey of world production and trade in chlorine placed 1935 and 1936 production at 600,000 to 700,000 metric tons, annually, of which more than 500,000 tons consisted of liquefied chlorine. World output in 1929 was placed at 400,000 metric tons, of which

about 300,000 was liquefied. The United States accounts for a substantial share of the world production.

Statistics compiled by the International Superphosphate Manufacturers' Association, London, show that the total world production of phosphate rock in 1936 was 11,346,500 metric tons, based on actual production figures for many countries and on estimates of output in Belgium, Soviet Union, France, and Spain. The revised total for 1935 was 12,029,700 tons, making an apparent reduction of nearly 700,000 tons for 1936. As a matter of fact, however, the production in terms of phosphoric acid showed an increase of about 247,000 tons over 1935, and the apparent discrepancy is explained by the varying bases taken for the Soviet Union production.

The trend of consumption, as indicated by compilations of world shipments of phosphate rock by the Phosphate Export Association showed that a peak was reached in 1937 when deliveries were reported at 11,931,900 metric tons, compared with 10,494,300 in 1936, and the previous high of 10,763,200 in 1929.

Total world output of superphosphate for 1936 was 15,621,600 metric tons, an increase of 1,173,000 tons over 1935, previously the highest figure on record, which exceeded that of 1930, the peak year until 1935, by 56,500 tons, according to the International Superphosphate Manufacturers' Association, London. However, the increase was not evenly spread over the world's geographic divisions: for example, Europe had a reduction of 113,000 tons, whereas America was up by 752,000 tons, Japan by 254,000, and Oceania by 271,000. The European position in 1936 is not strictly comparable with that of 1935, however, owing to the fact that for 1936 Russian superphosphate is computed at a much higher grade than for 1935. In addition the civil war in Spain has resulted in a reduction of about 605,000 tons in the output, and as superphosphate has been very intensively used in Europe for many years past, it is improbable that such a very large reduction in the output of one country would be made up by increases in other countries.

New high records were established by world nitrogen producers in the fiscal year ended June 1937 according to data compiled by the British Sulphate of Ammonia Federation, Ltd. Consumption increased 10.7 to a total of 2,675,000 metric tons. Synthetic plants operated on an average of 50 per cent of the world capacity placed at 3,900,000 metric tons. Of an estimated world-production total of nitrogen of 2,594,000 metric tons in 1936-37, byproduct of ammonum sulphate accounted for 407,000 tons, synthetic ammonium sulphate, 654,000 metric tons, cyanamide, 285,000 metric tons, nitrate of lime, 159,000 metric tons, Chilean nitrate 206,000 metric tons, and other forms of nitrogen, 883,000 metric tons.